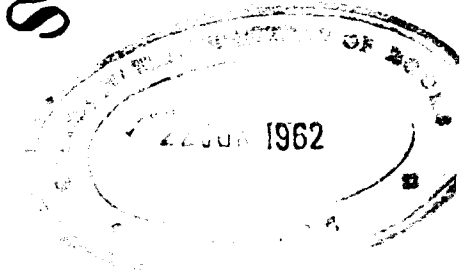


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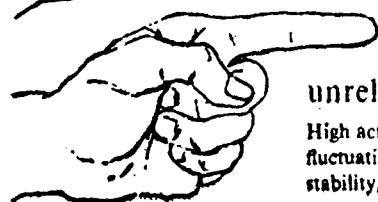
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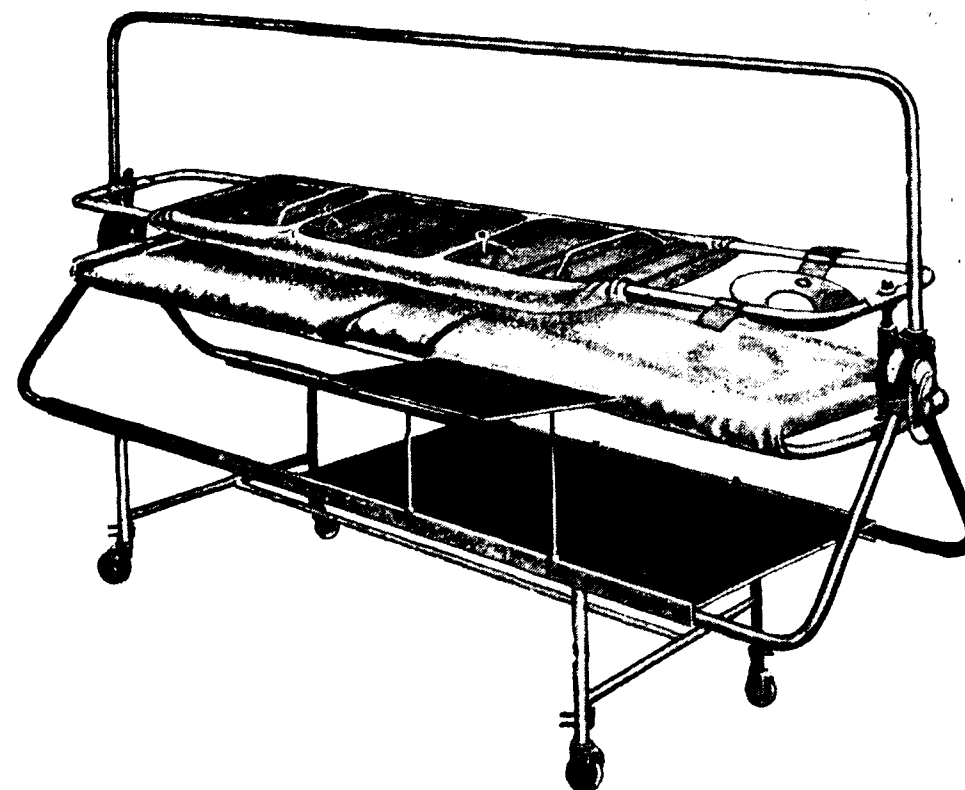
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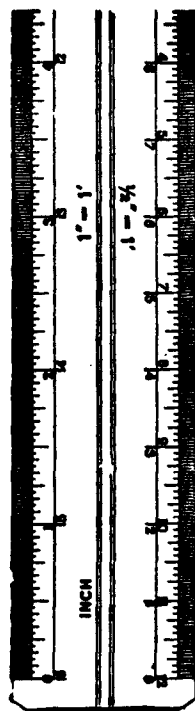
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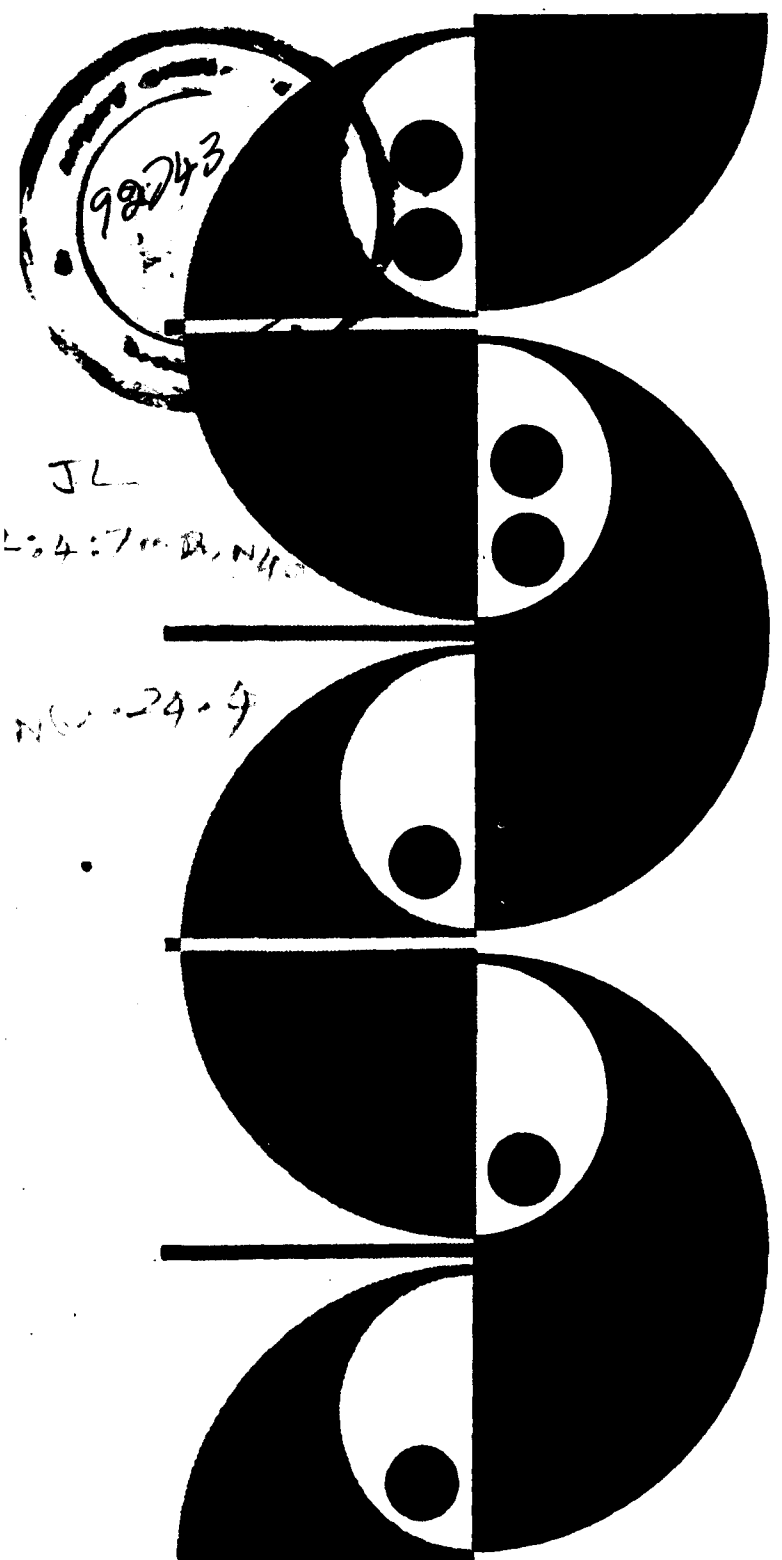
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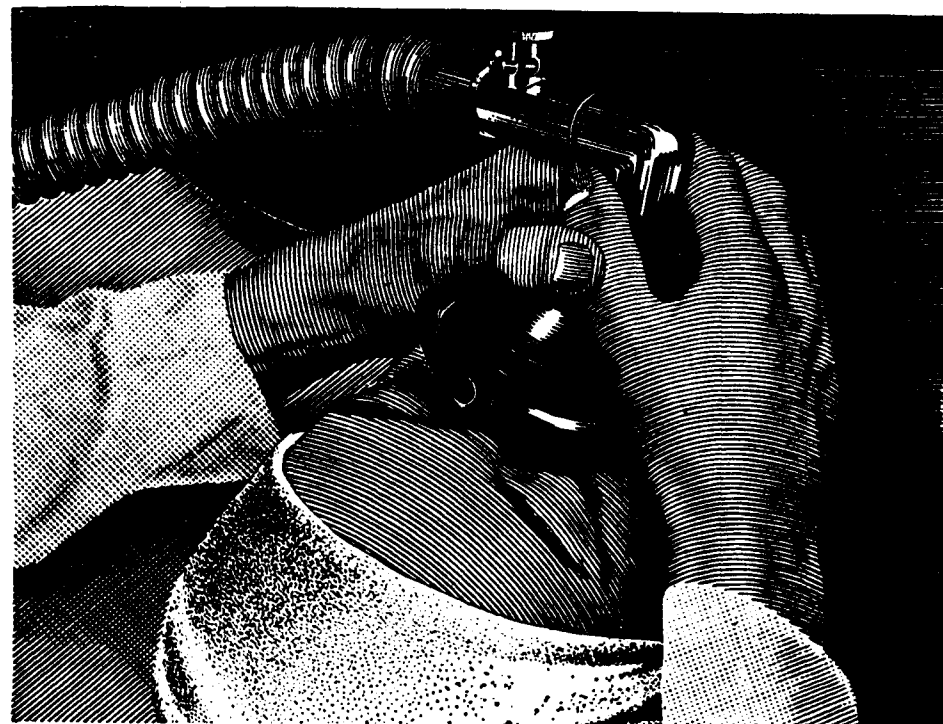
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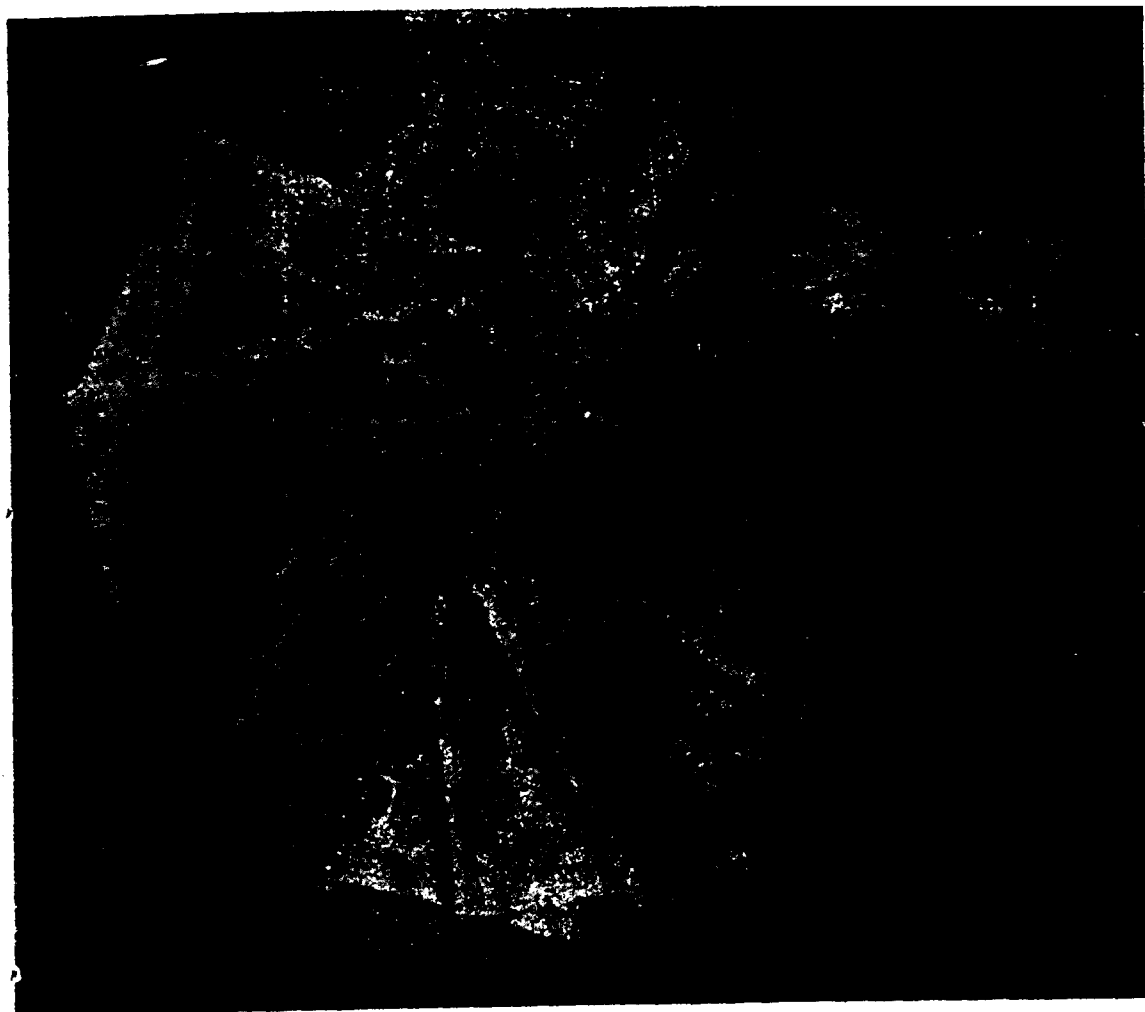
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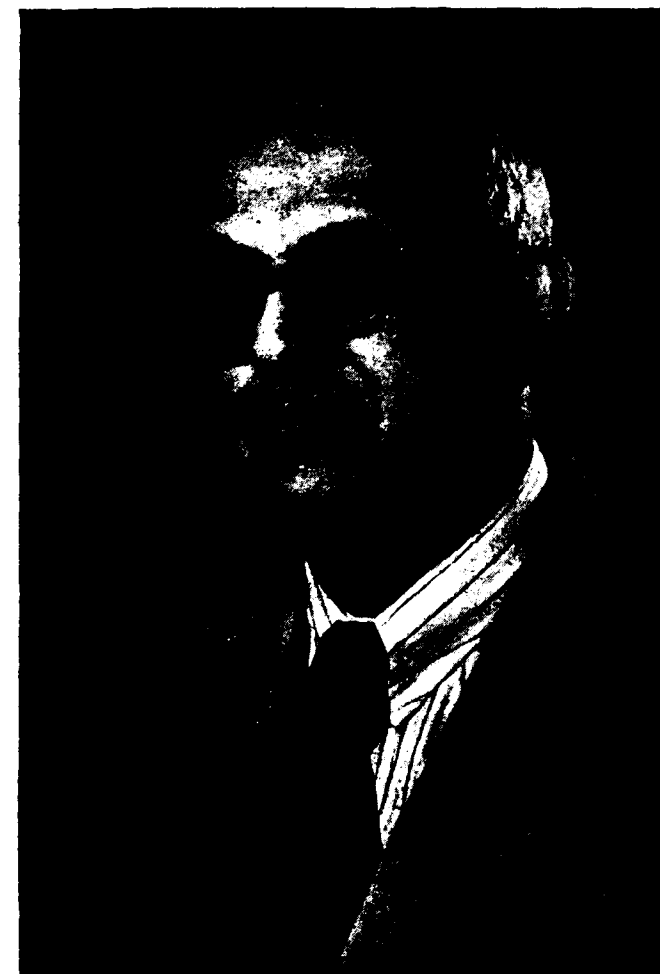


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Dr. R. N. COOPER

M.S. (Lond.), F. R. C. S. (Eng.)

Dr. Rustom Nusserwanji Cooper to whom this issue of the Journal is dedicated was born in 1893.

After going through his preliminary education at the Bharda New High School and Elphinstone College, Bombay, he joined the Grant Medical College. He graduated in 1915, after a fine academic record, winning all medals and prizes save one. Proceeding to England on a Government scholarship, he worked at the U. C. H., Middlesex and St. Bartholomew's Hospitals. He secured the Fellowship of the Royal College of Surgeons in 1919 and the Mastership in surgery of London University in 1920.

On his return to India in 1920, he was appointed for a short period of time as Honorary Surgeon at the G. T. Hospital, Bombay. In 1922, he was appointed by the Bombay University to give six post-graduate lectures on Surgical Tuberculosis. When the King Edward Memorial Hospital was founded in 1924, he was prevailed upon by Dr. Jivraj N. Mehta, who was then Dean of the K. E. M. Hospital to join the staff of the Hospital. His long and fruitful association with the K. E. M. Hospital, succeeded in creating a line of surgeons who remember not only his erudition but the incomparable artistry with which he taught. A master of the classical didactic school of clinical teaching, he brought a lucid intellect and a wealth of humour to his exposition of surgical problems.

In 1929, he was appointed Principal Medical Officer to the Bai Jerbai Wadia Hospital for Children.

Many honours have come his way. In the course of his career, he has been President of the Bombay Medical Union, President of the College of Physicians and Surgeons of Bombay, President of the Bombay Medical Council, Vice-President of the Indian Medical Association, President of the Indian Medical Association, Bombay Branch, Vice-President of the Bombay Presidency Nursing Council until its dissolution and is now a sitting member of the Nursing Council of the State of Maharashtra.

He has taken active interest in the formation of the Indian Branch of the International College of Surgeons, of which he was also, for several years the President.

He has served on the post-graduate examining boards of most of the Universities of India and he was appointed Inspector of Surgery by the Indian Medical Council to report on the facilities for education and standards of examination in the medical colleges in India and Burma.

One of the principal architects of the Association of Surgeons of India, with the late Dr. Pandalai and Dr. Joglekar, he has given both sustenance and inspiration to the edifice he helped to build.

As President of the Association in 1944 and as a member of the Governing Body of the Association for many years, his wise and moderating influence was always felt in the councils of the Association.

Among his many hobbies are photography, amateur cinematography, painting and astronomy and he has been a keen golfer.

Always anxious to widen his intellectual horizons, he has visited Europe and the United States of America three times in the surgical career.

The Journal extends to Dr. Cooper on his 69th birthday, its appreciation of his manifold services to the cause of surgery in India, and hopes that in the years to come, he will continue to guide and inspire his younger colleagues with the sense of dedicated service, which has been the mainspring of his life.

THE INDIAN JOURNAL OF SURGERY

Vol. XXIV

APRIL 1962

No. 4

LONGTERM FOLLOW UP STUDY OF PORTAL DECOMPRESSION OPERATIONS FOR PORTAL HYPERTENSION AND CIRRHOSIS OF LIVER*

BY

A. K. BASU, Calcutta.

Introduction

The benefits of shunt operations for portal hypertension secondary to cirrhosis of the liver have been questioned recently. Nachlas (1958) in a critical article attempted to collate the results of such operations performed by large numbers of surgeons and seemingly arrived at a number of conclusions which were mostly unfavourable as regards the short term as well as the long term benefits of such operations. This analysis was mainly based on statistical studies and did not take into consideration the patient as an individual. His main thesis was that the shunt operation did not confer any estimable benefit on the patient, that the overall survival after the operation after a year was no better than in those cases not operated on and therefore he said that the operation should not be persisted with. He was, however, of the opinion that surgical efforts should be made in other directions to control the bleeding varices

as the prognosis of patients treated conservatively was very dismal indeed. This article because of its provocative nature received much attention in various quarters and Hunt (1959) and Milnes Walker (1959) in England, who have had considerable experience of dealing with such patients, strongly contradicted both the premise as well as the content of Nachlas's judgment.

Our own experience of dealing with these cases is relatively limited as compared to some of the larger series published elsewhere, particularly in American literature. However, we have been interested in these cases since 1950 and have been able to follow up nearly all of our patients and in many cases have had them re-investigated after re-admission into the hospital. It was, therefore, natural to look back on this experience and try to answer some of the questions raised in this controversy from personal experience and observations.

*This paper was read at the 22nd Annual Conference of the Association of Surgeons of India held in Poona in December 1960.

This study seemed particularly appropriate for two reasons.

1. As is well known, the morphogenesis and the pattern of cirrhosis of the liver in India differ in some respects from those met with in Western countries and
2. As far as we know, there is no recorded series of cases in Indian literature wherein the results of shunt operations in this type of cases have been followed up for a sufficiently long period of time.

It may be that with further experience, some of the opinions mentioned here may need revision but the overall picture of the disease process with or without operation is sufficiently clear to make justifiable conclusions at this stage.

Material

The break-down of our cases year by year is shown in the accompanying table (Fig. 1). It would be seen that the numbers of cases who have had shunt operations are increasing progressively and that, in itself, is an indication that the benefits of the operations are being realized not only by the patient but what is more important by the physicians, who naturally deal with these patients initially and at first hand. Another reason, of course, is that with experience, the ability to deal adequately with such cases increases and more patients are referred to the surgeon.

The types of operations performed are shown in Table II (Fig. 2). The splenectomy operations have been included for two reasons. Some of these included attempted but failed shunt procedures—others were

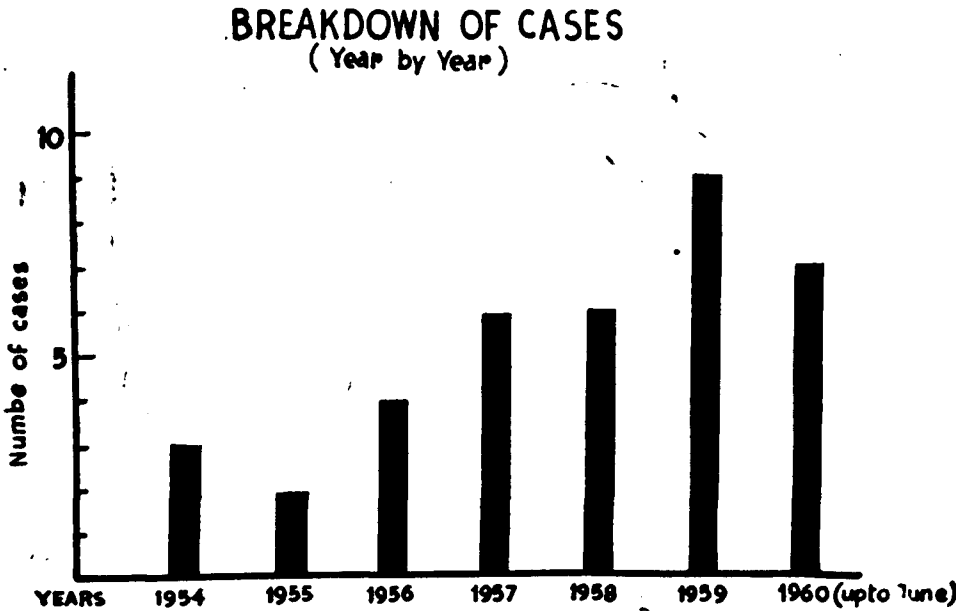


Fig. 1
Breakdown of cases of shunt operations year by year.

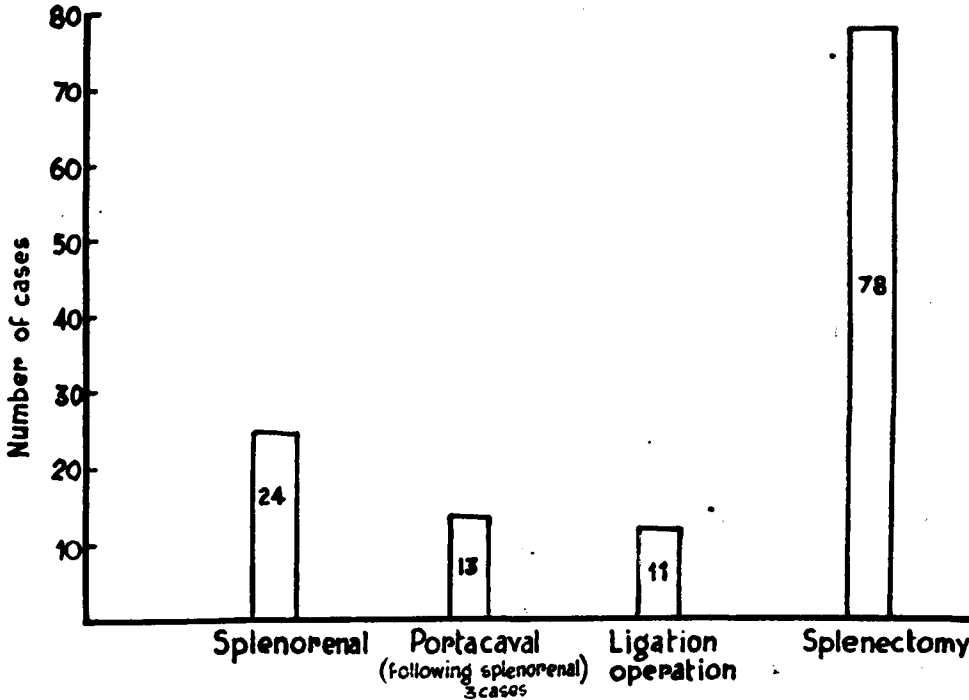


Fig. 2
Types of operations performed.

deliberated splenectomies because haemorrhagic episodes were not significant or because the portal venous pressure as measured at operation was not unduly raised. The ligation operation of Berman (1951) and Reinoff (1951) was only performed in very late cases of cirrhosis of the liver, particularly those with marked ascites, where the shunt procedure was considered unjustifiable from the risk involved.

Discussion

Perhaps the best way of dealing with many of the controversial problems would be to pose a number of critical questions and try to answer them as far as it is possible to do so.

Do venous shunts reduce portal venous pressure?

This question may appear to be superfluous because unless they did so, the shunt operations will have no value at all. However, in many writings on the subject, the reduction of the portal venous pressure has not been uniform and in some cases the resultant pressure has ranged above 250 mm. saline. It is difficult to give accurate statistical data regarding reduction of portal venous pressure following shunt operations. In our series, the pressure was taken by inserting a needle in the gastropiploic vein and connecting it to a saline manometer. Obviously this method has its limitations.

In general, however, we found that following well-executed porta caval shunts, the pressure was reduced by 150 mm. saline and splenorenal shunts reduced the pressure by 75 to 100 mm. saline. Many surgeons are of the opinion that sudden lowering of the pressure markedly may be detrimental to the liver and on that score favour spleno-renal to porta caval anastomosis. Arising out of this context, is the question of what is called the critical level of portal venous pressure below which the pressure must be reduced to insure against further recurrent haemorrhage. According to Blakemore, this figure is 300 mm. saline while others put this down to 250 mm. or even lower.

Is elevated portal venous pressure the sole factor in the causation of haemorrhagic episodes ?

An interesting finding in our series of cases was that cases which had massive bleeding episodes were not always the ones who had the highest venous pressure. This is illustrated in the following table (Table I). Another significant factor was that cases of portal hypertension due to extrahepatic obstruction appeared to bleed almost always although in many of them the venous pressures were not above 300 mm. saline. As opposed to this, many cases of intrahepatic obstruction did not bleed although their venous pressures were above the critical level. It seems, therefore, that there are at least two factors in the genesis of haemorrhagic episodes. One is the absolute value of the portal venous pressure and the other is the site of the obstructing element. The closer this obstruction is to the gastric and

Table I

Portal venous pressure and haemorrhagic episodes

Portal venous pressure as measured at operation.		
201-300 mm. saline	...	10 cases
301-400 ..	...	11 ..
401-500 ..	...	4 ..
Above 500 ..	...	1 ..
Portal venous pressure of less than 300 mm. saline - bled		
...	...	5 ..
Portal venous pressure of over 300 mm. saline did not bleed		
...	...	6 ..
Portal venous pressure of over 400 mm. saline did not bleed		
...	...	2 ..

Relation between elevated portal venous pressure and incidence of haemorrhage.

the oesophageal varices, the more is there the likelihood of bleeding when the pressure has reached a certain level. It may be that there are still other factors governing the causation of bleeding episodes and if that be so, the recurrence of bleeding even after significant reduction of pressure becomes understandable.

Do venous shunts prevent recurrence of haemorrhage ?

The incidence of post operative recurrent episodes of haemorrhage in our series of cases is illustrated in the following table :

Table II

Recurrence of Haemorrhage

		No. of cases
A. Shortly after operation	...	2
Within 1 yr. after operation	...	1
" 2 yrs. " "	...	4
Total	...	7 18.8%
B. Haemorrhage after splenorenal shunt	...	5 cases
Haemorrhage after Portacaval shunt	...	2 ..

Post-operative recurrence of haemorrhage.

Table III

Post operative mortality rate

	Rate.	Type of Operation.
Welch (1950)	31%	Both
Blakemore (1955)	23%	Both
Linton and Ellis (1956)	15.6%	Spleno-renal
Hunt (1958)	15%	Portacaval
Sedgwick and Hume (1959)	14.3%	Spleno-renal
	23%	Portacaval

Post-operative mortality rate (collected series).

By and large this figure of 18.8% compares well with the similar incidence of post operative haemorrhage reported by other workers. Blakemore (1952) reported 19% and Linton's (1956) figure was 20%. Another fact to be noticed is that the severity of the post operative haemorrhagic episodes is usually much less and in some cases, only of relatively minor nature. There were 2 exceptions. In one, massive haemorrhage occurred shortly after the operation and the patient succumbed quickly. In the other case, the post operative massive haemorrhage was followed by the development of intractable ascites and the patient ultimately died 2 years after the operation. It is postulated that in these 2 instances, the shunt must have got occluded due to thrombosis and must have been non-functioning.

In a few cases, bleeding recurred a few years after spleno-renal anastomosis. In 3 of these cases, porta-caval anastomosis was performed later and all these 3 cases did well-although one of them did have a minor bleeding episode subsequently.

When all these facts are taken into consideration, it is apparent that barring other eventualities and in general, a well constructed, adequately functioning, venous shunt does reduce both the frequency as well as the severity of haemorrhagic episodes in the cirrhotic—although it might not abolish this complication altogether.

Do venous shunts influence the overall prognosis favourably ?

The two factors to be considered under this category are :

1. The immediate mortality following the operation.
2. The long term survival of the patients.

The post operative mortality in this operation has been variously estimated as shown in the following table (Table III).

In general, the average mortality rate in this operation is computed as 20%. Our own mortality rates have been rather favourable (10.8%) (Table IV) and this

Table IV

Deaths

	No. of deaths.	Percent.
Operative Death	1	3
4 Months after operation. (From Haematemesis)	1	
From Ascites and Hepatic Failure	2	
(one after 6 months and another after 2 years)		
Total	4	10.8

Mortality rate in this series.

includes one immediate death from uncontrollable haemorrhage following operation, one 4 months later and 2 known late deaths from ascites and hepatic failure.

However to the mortality rate must be added the failures of the operation i.e.,

those cases, where the operation was attempted but had to be given up because of unsurmountable technical difficulties. That this eventuality arises sometimes is apparent from the writings of nearly all authors interested in this work and in the literature this failure rate is given as high as 10% of the operated cases. In our hands also, there have been a number of such instances but more often in the initial stages in the series. In the last 12 cases that have been operated on, only one case had to be given up

because it seemed impossible to separate the portal vein from the bile duct—the two structures were cemented together and a plane of separation could not be established even after the most painstaking effort.

The long term survival of the operated patients is a very interesting and rewarding study and if we compare our results with the fates of several non-operated series of cases reported by others, the contrast is very obvious (Fig. 3).

COMPARISON OF MEDICAL vs. SURGICAL (SHUNT) TREATMENT
(After Nachlas)

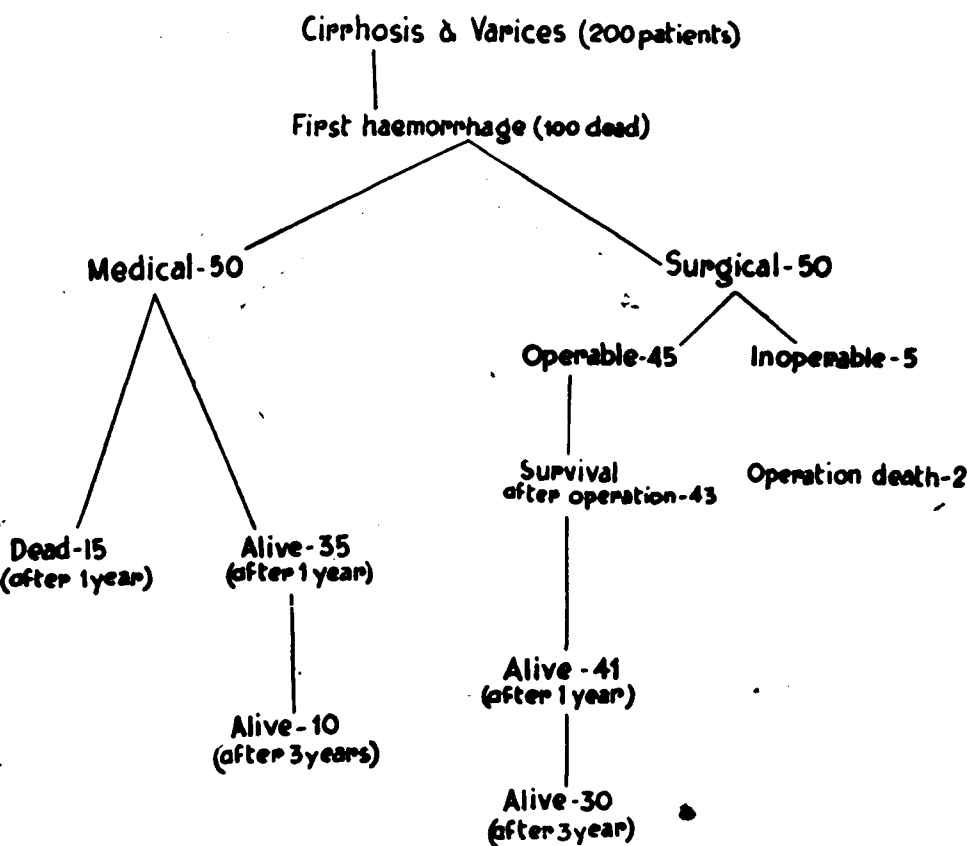


Fig. 3

Comparison of results of Medical versus Surgical treatment.

The non-operated series has been worked out on the basis of the data of several authors (Nachlas 1958). Linton (1958) on the basis of his large experience also arrived at similar conclusions and his estimate was as follows :

	Medical treatment	After Surgery
After 1 year ...	50% survival	80%
After 5 years ...	20% "	50%

The duration of the follow up period and the progress of some of our patients are listed in the following table (Table V). The longest follow up period is 6½ years and there are a number of cases going to 5, 4 and 3 years. The occupation and the work status of some of our operated patients are listed in the next table (Table VI). Some of them, as can be seen, are quite active and doing heavy manual labour. The accompanying photograph shows 3 patients (Fig. 4), one of whom is a police man, one a salesman of a surgical instrument manufacturing firm and the other a clerk.

Table V

Progress with Good Health and without Haemorrhage

	No. of cases
Doing well for 6½ years	2
" 5 "	1
" 4 "	2
" 3 "	4
" 2 "	6
" 1 "	7
Total	22

Post-operative progress of the patients.

Table VI

Occupation of the cases that are doing well

	No. of cases
Working as Police man	1
" Doctor	1
" Salesman	1
Office worker	6
Sedentary occupation	11
Total	20

Occupation of the cases that are doing well.



Fig. 4

Photograph of three patients - 5 years, 2 years and 1 year after operation.

Is there any difference after a shunt operation between the prognosis in a case of splenomegalic cirrhosis and cases of primary cirrhosis of liver?

Unlike western workers, we have had occasion to deal with a large number of cases of giant chronic fibrocongestive types of splenomegaly which are usually associated with a post necrotic type of cirrhosis and some of whom have episodes of haemorrhage. These cases are to some extent distinct from the cases of primary cirrhosis of the liver without significant splenomegaly (Basu 1958). The splenic veins in these former cases are of huge dimensions and in them we have invariably performed splenectomy combined with end to side spleno-renal anastomosis. At least 60% of our cases belonged to this type. A cogent question arises as to whether the prognosis in this type of cases is materially different from that in the second type of cases. While it is difficult to give a dogmatic opinion on the basis of a limited series of cases, it appears to us that unless the liver damage has reached very advanced and irreversible proportions, the overall prognosis after shunt surgery in cases of splenomegalic cirrhosis is, on the whole, better than in cases of primary cirrhosis of the liver. This is partly because the severity and the intensity of the haemorrhagic episodes are generally less in the former types of cases. A second important factor is that the removal of the hypertrophied spleen, by itself, confers considerable benefit on the patient. The liver parenchyma is spared of the load of the hypervolaemic splenic venous inflow and the bone marrow functions better without the restrictive effect of the hypersplenic check factors.

Do venous shunts influence ascites?

The numerous possible factors responsible for the genesis of ascitic fluid still await the investigator's close scrutiny and final verdict. Very possibly, it is not one factor that is responsible in any particular case and perhaps the responsible factor may be different in different cases. Of the important ones, hypoalbuminaemia, portal hypertension, hepatic outflow obstruction and the recent concept of secondary hyperaldosteronism, the last two seem to be much in favour at the present time. How far these factors are influenced by the conventional shunt operation is very doubtful. Undoubtedly we have had cases where preoperative ascites has subsided after spleno-renal or porta-caval shunts. The Police-man shown in the illustration came to us with significant ascites and had many episodes of haemorrhage. He has had no haemorrhage since 2 years after operation and has no ascites at present. However, one must remember that severe haemorrhagic episodes in cases of cirrhosis of the liver lead to advanced hepatic anoxia and often results in accelerated collection of ascitic fluid sometimes associated with hepatic coma. The disappearance of the ascitic fluid after conventional shunt surgery in such cases may be due not so much to the benefit of the operation itself but to the absence of severe bleeding episodes. Specific type of operations directed to combat hepatic outflow obstruction have been designed. There are two types available—the McDermot (1958) operation of double porta caval shunt and the side to side porta caval shunt popularized by Longmire (1958). We have had only one experience of the McDermot operation in a very advanced case of liver damage with huge ascites and although the operation could be successfully completed, the ultimate result was poor. The technical difficulties of the operation are such as to

preclude its general application. McDermot (1960) has now performed 17 of these operations and his initial enthusiasm seems to have diminished somewhat. The side to side shunt is credited also to relieve hepatic outflow obstruction. A possible grave drawback of this operation pointed out by Linton (1959) and others in a recent discussion is that a side to side shunt might short circuit the hepatic arterial blood in a retrograde fashion through the newly constructed anastomosis and thus the already damaged liver parenchyma might be gravely jeopardized.

It is quite clear therefore that although shunt operations are known to relieve ascites in some cases by preventing or minimising acute haemorrhagic episodes and resulting intermittent hepatic anoxia—no fool proof type of shunt has yet been designed to relieve longstanding or intractable ascites in every case.

Which type of venous shunts are to be preferred?

Opinions markedly differ as to the value of the 2 types of venous shunts—spleno-renal and porta-caval. In England Prof. Milnes Walker as well as Mr. Alan Hunt have condemned spleno-renal shunt as the one more likely to be associated with post operative thrombosis and consequent recurrence of haemorrhage. In a symposium on this subject held at the Annual Meeting of the Association of Surgeons of Great Britain and Northern Ireland held in Belfast in 1958, this point was emphasized by several speakers. Perhaps ordinarily there is a considerable element of truth in this observation. However, we would like to point out that in the cases of splenomegalic cirrhosis that we have dealt with, the splenic vein is considerably enlarged—often of the size of the inferior vena cava and in them, a well executed spleno-renal shunt is less likely to thrombose quickly. This is borne out by the

fact that 5 out of 23 cases of spleno renal shunts have bled as compared to 2 of our 14 porta caval. The difference is there but perhaps not as marked as is generally believed and certainly not sufficient to condemn the spleno-renal shunt operation. The one important advantage of the spleno-renal shunt procedure is that the large hypertrophied and hyperactive spleen is removed at the same time. The mortality rate of the spleno renal shunt is generally thought to be less than of the porta caval shunt. Further, because the portal blood is not entirely shunted from the liver parenchyma, the incidence of liver failure is very uncommon. In a well documented study Hallenbeck et al (1958) from the Mayo Clinic studied the comparative results of a series of cases treated by splenectomy alone, spleno-renal shunt and porta caval shunt and came to the conclusion that in their hands spleno-renal shunt gave results superior to those after splenectomy alone or end to side porta caval shunt.

Is there any harm in suddenly lowering portal venous pressure?

The cirrhotic liver is particularly susceptible to all kinds of trauma. Diversion of the portal blood is thus likely to harm the liver in some ways. Total diversion by porta caval shunt is therefore more injurious than the spleno-renal shunt procedure. Most observers think that there is a phase of depression of hepatic function following the shunt procedure which is usually temporary. Some observers have reported a large incidence of post shunt neuropathic symptoms—in some cases leading to or bordering on hepatic coma. In our cases, the incidence of hepatic dysfunction symptoms have been most uncommon and there has been no case of coma. On the other hand, we have seen many cases of hepatic coma following sudden and severe episodes of haemorrhage. It appears to us therefore that while the danger of

hepatic depression following a shunt procedure cannot be entirely discounted, its frequency and severity, particularly after a spleno-renal shunt, has been unduly overstressed.

Conclusion

We have attempted to bring out the salient points of shunt operations in cases of cirrhosis of the liver and portal hypertension. This study is based on a personal series of 37 completed cases followed up from 6 months to 6½ years. Our criteria for performing this operation were the history of one or more severe haemorrhagic episodes and portal venous pressures above 300 mm saline as recorded during the time of the operation. We have tried to answer many of the controversial points raised about the short term and the long term efficacy of the operation. We feel confident that in our series of cases, the operation has resulted in considerable benefit to the patients. The operative mortality has been relatively low. There has been substantial immediate reduction of portal venous pressure; the incidence of postoperative recurrence of haemorrhage although not entirely abolished has been markedly diminished; the ascites when present pre-operatively has disappeared completely in few patients; and the long term survival rate has been markedly

improved as compared to large collected series of non-operated cases in similar straits and many of the patients have returned to useful occupations.

We feel that the pattern of cirrhosis of the liver associated with large chronic splenomegaly (which abound in our part of the country) is in some respects different from those recorded in western literature and that in such cases, splenectomy combined with lino-renal shunt is particularly appropriate. We would reserve the porta caval shunt procedure for the primary cirrhotic who has no significant splenomegaly and who has many episodes of severe bleeding. The incidence of hepatic dysfunction symptoms, particularly coma, has been insignificant in our series of cases and it appears to us that this grave complication has been unduly overstressed.

A word of caution is perhaps appropriate at the end. Too much should not be expected of the shunt operations. They do nothing to improve liver function or structure and it would be idle to expect the operation to reverse the state of liver damage which has nearly reached its end. If we remember these limitations and if the cases are well chosen and the operation well performed, the results—short term and long term—are likely to give satisfaction.

REFERENCES

1. Basu, A. K.: Ann. R. C. S. of England, 24, 137, 1958.
2. Berman, J. K., Muller, L. P., Fisch, C. & Martz.: A. M. A. Arch. Surg., 63, 223, 1951.
3. Blakemore, A. H.: S. G. O., 89, 357, 1949.
4. Blakemore, A. H.: S. G. O., 94, 443, 1952.
5. Blakemore, A. H.: J. Chr. Dis., 2, 70, 1955.
6. Hallenbeck, G. A., Comess, M. S., Wolloeger, E. E. & Gage, R. P.: A. M. A. Arch. Surg., 78, 774, 1958.
7. Hunt, A.: B. M. J., 2, 1300, 1958.
8. Lanton, R.: Am. J. Med., 24, 941, 1958.
9. Linton, R. & Ellis, D. S.: J. A. M. A., 160, 1017, 1956.
10. Long Mire, W. P., Mulder, D. G., Mahoney, P. S. & Mellinoff, M. D.: Ann. Surg., 147, 881, 1958.
11. McDermot, W. V.: New Eng. Jr. Med., 259, 897, 1958.
12. Nachlas, M. M.: Ann. Surg., 148, 169, 1958.
13. Reinoff, W. F.: Bull. John Hosp., 88, 368, 1951.
14. Sedgwick, C. E. & Hume, H. A.: A. M. A. Arch. Surg., 78, 359, 1959.
15. Walker, R. M.: B. M. J., 2, 1118, 1958.
16. Welch, C.: New Eng. Jr. Med. 243, 598, 1950.

—Received for publication on 12-1-1961.

RECONSTRUCTIVE SURGERY OF BLOOD VESSELS

(A Clinical Report of 106 cases treated surgically)

BY

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It is customary in the beginning of a paper, to draw a historical sketch of the subject and, though this traditional aspect is often sterile in its influence, it is most inspiring in this particular field, perhaps because the growth of vascular surgery falls within the purview of contemporary history.

All names in this field, like roads to Rome, lead to that of the towering figure of Carrel.^{1,2} It could be stated today, without fear of exaggeration, that there is possibly no facet of reconstructive surgery of blood vessels which was not conceived of, experimented upon, and in some instances even clinically applied, by Alexis Carrel fifty years ago. Modern techniques of anastomosis, principles of triangulation, various plastic procedures for altering and widening vascular calibers had all been worked out in the early nineteen hundreds by Carrel. In the field of vascular transplantation, and also in the use of non-living tissue for vascular replacement, Carrel's pioneering principles still govern our work.

In this paper we have tried to summarise briefly our experiences with the first 106 cases in which some kind of vascular reconstructive or allied operative procedure was employed during the period of the last eight years. We have grouped reconstructive procedures etiologically, in order to more adequately cover the subject, and illustrated them with our own case reports, supplementing wherever possible with our opinions and philosophies.

Indications for vascular reconstruction have been grouped as follows (after Rob³):

1. *Congenital vascular anomalies*:
 - (a) Congenital coarctation of aorta.
 - (b) Congenital arteriovenous aneurysms.
 - (c) Congenital arterial aneurysms.
 - (d) Vascular tumours.
 - (e) Angiomatous malformations.
2. *Vascular injuries*:
 - (a) Injury of blood vessels.
 - (b) Traumatic arteriovenous aneurysms.
3. *Aneurysms*:
 - (a) Aorta.
 - (b) Peripheral arteries.
4. *Embolisms*:
 - (a) Aorta.
 - (b) Peripheral arteries.
5. *Thrombosis*:
 - (a) Primary thrombosis.
 - (b) Thrombosis in association with atheroma.
 - (c) Thrombosis in association with arterial inflammation.
 - (d) Thrombosis in association with collagen disorders.

Congenital Vascular Anomalies

(Congenital coarctation of the aorta)

The classical examples of congenital arterial anomalies is coarctation or narrowing of the artery, and this is classically

shown in its incidence in the aorta. Other large vessels are also occasionally affected, such as the pulmonary artery or branches of the aorta. The classical situation of aortic coarctation is at the site of the ligamentum arteriosum but it can occur anywhere else. Our operative experience of coarctation of the aorta runs to only 11 cases of which 3 were treated by excision and grafting and 8 by some type of excision suture or reconstructive procedure.

In this group, only 9 out of the 11 could be definitely said to be congenital, and the reasons for saying so are that in these 9 cases there was no evidence of arterial obliterative disease of the aorta. Two others were elongated stenotic segments of the descending thoracic aorta, turned out on further examination to be obliterative diseases and will be commented on in detail elsewhere. The 9 cases of congenital coarctation of aorta varied from age groups 3 to 28 years. In one, an aortic homograft measuring about 6 cms. was used for replacement of the coarctate segment (Case Report 1). Follow up after six years has shown that the homograft is functioning well and is normal in appearance. In another case of congenital coarctation (Fig. 1) the coarctate segment was excised and replaced with a knitted dacron graft 4 cms. in length. Excision of the coarctate segment and suture of the divided ends was carried out without difficulty in 6 cases (Case Report 2). In one case, modification of the excision treatment was carried out as described by Milnes Walker and Hoxton in 1953 (Case Report 3). In this procedure the coarctate segment is not excised but incised under clamps in a semi-circle manner and the two ends of the aorta anastomosed, thus obliterating the need for dissecting the coarctate segment. It is not possible for us to form an opinion in a single case, but it is true that there is



Fig. 1
Suprasternal aortogram of a case of coarctation of aorta.

difficulty in approximating the vessels together and we feel that this particular technique has a very limited application and, unless the ligamentum arteriosum or ductus arteriosus is long, the vessel ends cannot be straightened and brought down for accurate apposition.

Case Reports

Case Report 1.—Coarctation of aorta. Excision of coarctate segment and replacement with graft.

K. R., a female, 28, was admitted for palpitation, exertional dyspnoea, pain in the chest and amenorrhoea 1½ years. Examination revealed delayed and feeble femoral pulsations. B.P. 200/100 - arm, 110/70 - leg. Grade two systolic murmur in the third left space. Investigations - X-ray chest-rib notching, left ventricular hypertrophy. Angiography - adult type coarctation of aorta, E.C.G. - left bundle branch block. Operation - left thoracotomy through 4th rib bed. Coarctation of aorta 1½ cm. beyond the origin of the left subclavian artery. Coarctate segment was resected and a homograft measuring 6 cms. long, 11 mms. proximal diameter, 9 mms. distal diameter was anastomosed by 5 zero arterial silk - continuous over and over suture (Fig. 2). Uneventful recovery.

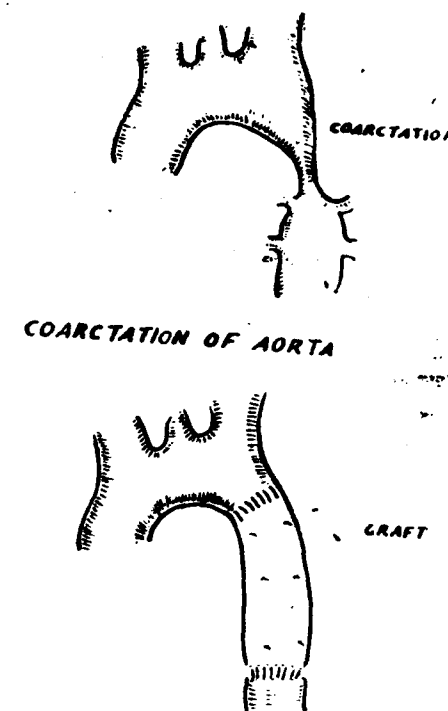


Fig. 2
Excision of coarctation of aorta and replacement with a graft.

Follow up after 6 years - good femoral pulsations. B.P. 120/80 - arm, 135/95 - leg. X-ray chest - no aneurysmal dilatation or calcification. Heart size normal, E.C.G. - no bundle branch block. Recently her menstrual period also has started. Post-operative aortogram - graft functioning well. No narrowing and no aneurysmal changes.

Case Report 2.—Coarctation of aorta. Excision of coarctation and suture repair of aorta.

S. M. A., female, 22, was brought to us for attacks of dyspnoea and tingling and numbness of both inferior extremities for 1 year. Examination revealed that lower limbs were cold, pulsations of abdominal aorta were feeble, strong pulsation of intercostal vessels, short systolic murmur at the left sternal border, systolic murmur along the intercostal vessels posteriorly. B.P. 140/80 mm. Hg. - arm, not recordable in leg. X-ray chest - left ventricular hypertrophy, rib notching. E.C.G. - within normal limits. Exploratory thoracotomy through 5th rib bed, coarctate segment 2 cms. distal to root of the left sub-clavian artery, coarctate segment 7 mm.

long. Aorta mobilised, intercostals and right bronchial ligated and cut. Patent ductus arteriosus ligated and cut. Aorta clamped above and below the coarctation and excised. End to end suture repair carried out by continuous suture and a few interrupted sutures with 4 zero silk. On removing clamps fall of 60 mm. in blood pressure was noted. Patient has done very well.

Five other cases operated by the same technique have done well and have been followed up for more than four years.

Case Report 3.—Coarctation of aorta. Milnes Walker and Hoxton technique.

K. S., male, aged 18, admitted for bouts of acute headache, palpitation, exertional dyspnoea. Examination revealed feeble femoral pulsations. B.P. 170/80 mm. Hg. upper extremity, not recordable in lower extremity. Systolic murmur at the apex and back. Diastolic murmur third space left sternal border. X-ray chest - rib notching, E.C.G. - within normal limits. Exploratory thoracotomy through 4th rib bed. Adult type of coarctation just beyond the origin of left subclavian artery, post-stenotic dilatation. The upper segment was acutely tucked in at the junction of aorta and ligamentum arteriosum producing a sharp kink at that level. Wedge excision from the sharply angulated aspect of coarctate segment posterolaterally and restoration of continuity of the lumen by interrupted suture of the edges of the defect were carried out. Ligamentum arteriosum excised between ligatures. Pulsations returned to lower extremity. On 40th post-operative day patient developed tearing pain in the chest and swinging temperature. Blood culture - coagulase positive, penicillin resistant staphylococci. Erythromycin exhibited. Patient expired on 46th post-operative day. Autopsy revealed ulceration at the site of anastomosis with leakage and formation of false aneurysm which had ruptured into the pleural cavity.

(b) *Congenital arteriovenous aneurysm.*—Congenital arteriovenous aneurysms are relatively rare and we have so far met with only three such cases. One was in the cheek of a man of 30 years of age without any history of injury who came with pulsatile swelling of the right cheek. This was an arteriovenous aneurysm of facial artery and adjacent veins. After ligating the feeding vessels the A.V. aneurysm was excised.

Multiple staged operative procedures of ligation of arteriovenous communications, feeding vessels etc. and obliteration of blood spaces are required for the

treatment of large arteriovenous communications of extremities which undoubtedly present a very formidable surgical problem.

Two interesting cases of congenital arteriovenous aneurysm of upper extremity have been recorded below.

Case Report 4.—Congenital arteriovenous aneurysm of upper extremity. Multiple ligation of A. V. fistulae and ligation of subclavian artery.

P. R., male, 25, was admitted for painful swelling of right forearm - 4 years, and gangrene of fingers for 6 months. History of several bouts of haemorrhage from gangrenous fingers. No history of trauma. Examination revealed swelling of right forearm, thrill all over the right upper arm and forearm, continuous to and from murmur over the upper arm and forearm. Arteriogram - no definite aneurysm seen. Exploration of the upper arm and forearm revealed multiple small arteriovenous communications between the brachial artery and the adjacent veins. These were carefully detected by auscultating with a sterilised stethoscope, dissected and ligated. In the forearm there was a large arteriovenous aneurysm in connection with branches of ulnar artery and the accompanying veins. It was dissected and excised. The operation did not prove of any great benefit as the haemorrhage continued from fingers. The subclavian artery was ligated. Ligation of subclavian artery proved to be of immediate benefit - the haemorrhage stopped, the size of the limb shrank. A line of demarcation of gangrenous fingers was formed.

Case Report 5.—Congenital arteriovenous aneurysm - upper arm ligation of subclavian artery and obliteration of aneurysmal sac.

R. P., male, aged 16 years was admitted for swelling of the left side chest, shoulder and amputated left arm for 5 years (Fig. 3). The swelling started when the patient was two years of age and progressively increased. Five years ago there was a severe bout of spontaneous haemorrhage from the left hand, for which an emergency amputation was performed through the comparatively normal left upper arm. Following the amputation there appeared swelling on the amputation stump which gradually progressed towards the adjacent parts of the chest wall. Examination revealed pulsatile swelling of the left side of the chest, shoulder and left upper arm. Systolic murmur was heard at the root of the neck on the left side. Blood pressure in the right arm was 120/70. The heart was enlarged, the apex beat being in the left sixth

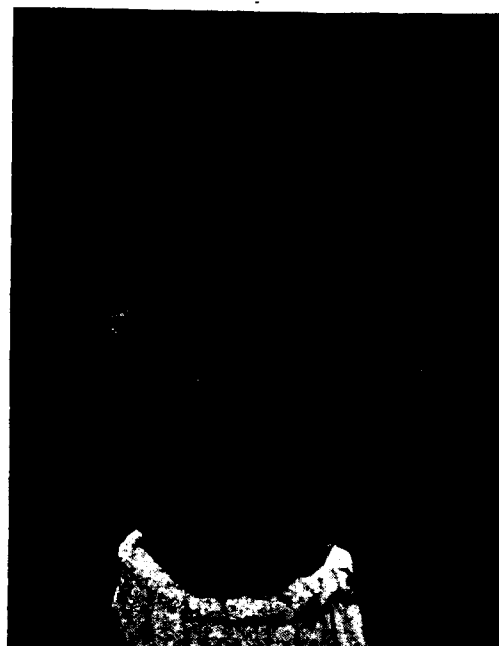


Fig. 3

Clinical photograph of a case of congenital arteriovenous aneurysm of an amputated upper arm.

interspace half inch outside the midclavicular line. Skiagram of the chest revealed enlarged left ventricle. Intravenous angiogram showed large blood spaces of the upper arm. The left subclavian artery was ligated in its intrathoracic course. The left subclavian artery was very large in size. Immediately on ligation of the vessel, the swelling of the chest wall, shoulder and the arm was reduced considerably in size and its pulsatility disappeared. Later gangrenous changes supervened in the amputation stump, from which secondary haemorrhage occurred. Multiple ligation of the feeding vessels and obliteration of aneurysmal spaces was performed in stages. The amputation stump is now well healed and the entire swelling of the chest and the shoulder is considerably diminished in size. Patient refused further surgery and was discharged.

Congenital arterial aneurysm

The majority are found within the cranium - "Berry", aneurysms. Congenital arterial aneurysms of other arteries do occur from time to time in other parts and

we have had two such cases. One affecting inferior labial artery and another of the left radial artery of the limb. Both were small arterial aneurysms and were excised without difficulty.

There is yet another case of popliteal aneurysm which has been included elsewhere but may also be considered in this group of congenital aneurysms. The patient in addition to having the popliteal aneurysm, had multiple exostosis of bone, dwarfism, and congenital cystic disease of the lungs and kidneys. The aneurysm was excised and subjected to pathological examination which revealed no other disease except degenerative arterial changes. However, it is possible that he developed post-stenotic dilatation of the popliteal artery due to the osteoma pressing on the artery at that level.

Vascular tumours and angiomatous malformation of limbs

We had three cases of angiomatous malformation of limbs. These angiomatous malformations usually present themselves as single and sometimes multiple gigantism of the limbs which may be associated with skeletal growth of the limb and other tissues (Fig. 4). In two there was angiomatous malformation of lower limb. There were markedly dilated venous system of the limb without any definite signs of arteriovenous communication. The venous system would fill up in dependency and empty on pressure. The entire angiomatous mass in both cases was excised. Both patients have done well.

2. Vascular Injuries

(a) *Injury of blood vessels.*—This is essentially a field of the military surgeon and in civilian practice one meets this relatively less frequently. Eight cases of arterial injuries have been managed by us during this period. In five, suture repair of lateral

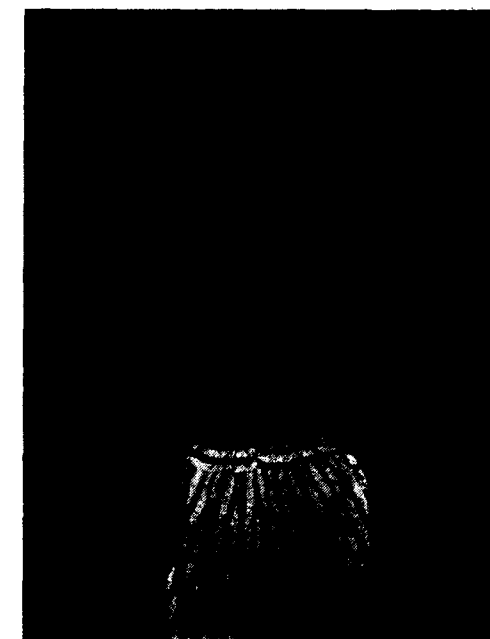


Fig. 4

Clinical photograph of a case of angiomatous malformation of upper extremity and back.

tears was carried out. Excision and anastomosis was not done in any, but in two cases autogenous vein graft was used to repair an injury of the brachial artery. This transplant did not work satisfactorily in one case and the impending gangrene for which operation was performed was not checked, amputation was the result. In another case of injured brachial artery, an autogenous venous graft 3.5 cms. in length was used to replace the injured segment. The graft functioned well. The patient died on 14th postoperative day due to progressive renal shut down. Autopsy revealed changes of lower nephron nephrosis in the kidneys. The grafted segment of vein was patent. In yet another case, a teflon graft 5 cms. in length was used to replace injured femoral artery. It is our impression that reconstruction of the artery is of prime importance after an injury. It must be done early and well before thrombosis, infection or gangrene have crept in.

(b) *Traumatic arteriovenous aneurysm.*—Traumatic arteriovenous aneurysms occur following either a blunt injury or a penetrating injury. In our series, six had followed a blunt trauma; two were on the foot, one in the leg, one in the forearm, one in the palm (Fig. 5) and one on the face. In all these cases the arteriovenous aneurysm was dissected and quadruple ligation and excision was done. One of the patients was a male aged 30 years, who came for a non-healing ulcer on the foot. There were two A. V. aneurysms, one in connection with anterior tibial artery and vein, and another in connection with a branch of posterior tibial artery and accompanying vein. Both the aneurysms were successfully excised. The chronic ulcer healed rapidly after the operation.

In the two A. V. aneurysms which followed the penetrating injury, there was one case of a bullet wound injury of the calf which was followed by A. V. aneurysm of posterior tibial artery and vein. The aneurysm was excised after ligation of the vein and the artery was reconstructed. Patient did well.



Fig. 5

Arteriogram showing arterio venous communications in the palm.

Case Report 6.—Traumatic arteriovenous aneurysm of facial artery and vein. Quadruple ligation and excision of aneurysm.

S. D., male 15 years, came with painful swelling on left side, lower jaw - 1 year. History of penetrating injury due to metal piece. X-ray showed the metallic foreign body. Exploration was done to remove the foreign body. There was a small arteriovenous aneurysm between facial artery and vein eroding the bone. Quadruple ligation and excision of the sac was done.

3: Aneurysms

(a) *Aneurysm of aorta.*—Aneurysms form a major portion of reconstructive work and our own experience indicates that this is a field of growing rewards in reconstructive surgery. In the first fifty years of this century, operative treatment of aneurysm of aorta mainly consisted of attempts at excision or occlusion *in situ*, and reconstructive surgery was limited. The present day concept of the treatment of aneurysm by excision and restoration of blood flow did not evolve until after 1950, and the large series conducted by DeBakey⁴, Cooley and Creech demonstrate the part that reconstructive surgery can play in the treatment of aneurysms. Others have also recorded their

experiences and which experiences^{1,6,7} have also been similar.

We have operated on 44 cases of aneurysms in which 31 were aortic and 13 were of peripheral arteries. Of the 31 cases of aortic aneurysms, reconstructive surgery was done in 16 and cellophane wrapping in 7, and arteriovenous shunt distal to the aneurysm in 2. In 6 nothing was attempted after exploration. Of the aortic aneurysms treated by some sort of reconstructive procedure, 6 were in the abdominal aorta, 3 in the thoraco-abdominal, and 7 in the thoracic aorta. The types of reconstructive surgery done were - exo-aneurysmorrhaphy - 2 cases, excision of saccular aneurysm and suture repair of aorta in 3 cases, complete excision of aneurysm and replacement with graft in 9 cases. Excision of aneurysm *in situ* and restoration of continuity of aorta with graft was performed in 2 cases.

Saccular aneurysms of the arch of the aorta are invariably syphilitic in origin. They occur commonly at the junction of ascending and arch of aorta or near the descending part of the arch. We have successfully excised two of such aneurysms and repaired the aorta.

The fusiform aneurysms of arch of aorta present formidable problems. Complete excision of aneurysm and replacement of arch with synthetic graft was attempted in one case, but the patient expired soon post-operatively. Two cases of aneurysms arising from the descending thoracic aorta were partially excised and replaced with graft. In both cases a part of the sac of aneurysm eroding into the chest wall was left unexcised.

It is our experience that aneurysms of the aorta in many cases, especially abdominal ones, have mixed arteriosclerotic and syphilitic factors. The aneurysms of the ascending and transverse portions of the

aorta offer rather poor clinical material for excisional surgery or reconstructive surgery, but we have had the opportunity of treating a few of these.

Resection of aneurysm and grafting was performed for five aortic aneurysms - 3 were abdominal and 2 thoraco-abdominal. Complete excision of aneurysm and grafting was done for all the 3 abdominal aneurysms which were arising about half an inch below (Case 5) the origin of renal artery. In 2 of these, a bifurcation graft was used as the aneurysms involved the common iliac arteries. The thoraco-abdominal aneurysms could be only partially excised and grafting was made in front of the remnants of the sac.

Case Report 7.—Abdominal aortic aneurysm - Resection and grafting.

J. S., 50, came to us for pain in the back and both thighs - 1 year, intermittent claudication - 6 months. Examination revealed pulsatile lump in the umbilical region 4" × 2½". Both femoral pulsations absent. B. P. upper extremity 112/70 mm. Hg., B. P. lower extremity not recordable. Blood serology - negative. Blood cholesterol 190 mg.%. Plain x-ray of abdomen - erosion of lumbar vertebrae. Aortogram - aneurysm below the renal arteries. Under moderate hypothermia laparotomy was performed through a long midline incision. There was a fusiform aneurysm of abdominal aorta below the renal arteries and involved right common iliac, left internal, and external, iliac arteries. No pulsations in both external iliacs. The aneurysm was completely excised (Fig. 6) the iliac arteries were dissected till patent lumen could be seen. A bifurcating homograft was used for replacing the aneurysm (Fig. 7). Good pulsations returned to the distal arteries. Post-operatively the back pain was relieved. Follow up after one year has revealed that femoral pulsations are not palpable. The B. P. in lower extremity is not recordable, and patient still complains of intermittent claudication. Aortography done recently has revealed complete aortic block below the level of the superior mesenteric suggestive of thrombotic occlusion of the homograft. This is, in fact, the only case of homograft having undergone thrombotic occlusion in this series.

In two other cases of abdominal aortic aneurysms homografting has been successfully done. Both were atherosclerotic aneurysms, one in a male aged 71



Fig. 6

Specimen of a fusiform aneurysm of abdominal aorta arising below the renal arteries and involving both the iliacs.

years, and another in a female aged 35 years. Surprisingly, the aorta was quite healthy and the anastomosis could be done satisfactorily.

Case Report 8.—Aneurysm of thoracoabdominal aorta. Excision of aneurysm and replacement with graft.

D. G., Male, 36, was admitted for pain in the abdomen and chest - 2 months. Loss of appetite and

constipation - 2 months. Examination revealed a pulsatile abdominal lump extending from under the left costal margin and occupying epigastrium, left hypochondrium and left lumbar region.

Under moderate hypothermia (31°C) thoracotomy was performed through the 9th rib bed. A large saccular aneurysm extending from above the diaphragm up to the origin of renal arteries was exposed. The coeliac axis and superior mesenteric artery both were arising from the aneurysmal sac (Fig. 8). The aneurysm was partially excised and a graft 13.5 cm. long, 1.9 cm. diameter was anastomosed to the proximal and distal aorta in front of the partially resected aneurysm. The distal stumps of coeliac and superior mesenteric arteries were anastomosed to two large branches of the aortic graft. (Fig. 9). At the end of the operation good pulsations returned in the distal aorta and in the mesenteric artery. The circulation was arrested for one hour and thirty-five minutes for purposes of excision and anastomosis. Immediate post-operatively, the urine output was not satisfactory but it soon improved. On 12th post-operative day patient had a haemetemesis and melaena. Exploratory laparotomy revealed clots in small intestine which were otherwise normal. Mesenteric pulsations were felt. The patient recovered from this but developed a similar episode on the 22nd post-operative day and expired. No operation was done. Autopsy was not available. We wonder whether, in this case, there developed an aortoduodenal or aortojejunal fistula which has been described as a complication of homografting for abdominal aneurysms.⁴

In another case of aneurysm of abdominal aorta involving both renals (Fig. 10), after bypassing

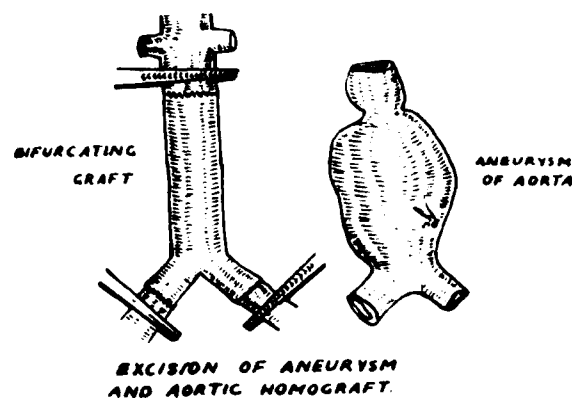


Fig. 7

The technique of excision of aneurysm of abdominal aorta and replacement of bifurcation graft.



Fig. 8

Aortogram showing aneurysm of thoracoabdominal aorta involving both coeliac and superior mesenteric arteries.

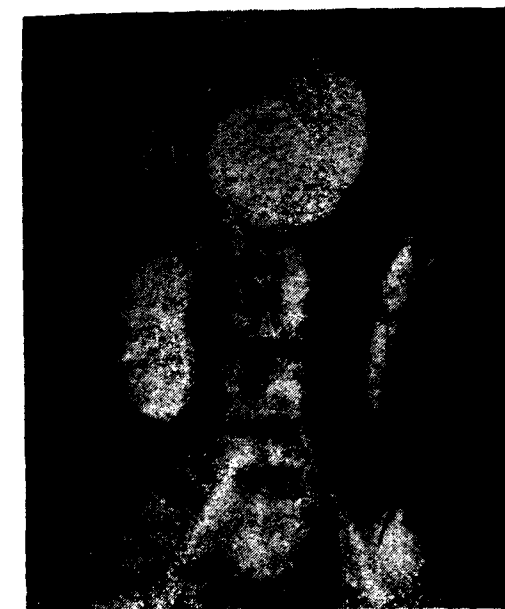


Fig. 10

Aortogram showing aneurysm of the abdominal aorta involving both renal arteries.

the aneurysm with graft, both renal arteries and coeliac axis were sutured to the aortic graft with tubular knitted dacron grafts (Fig. 11).

Case Report 9.—Saccular aneurysm of thoracoabdominal aorta. Partial excision and suture repair of aorta.

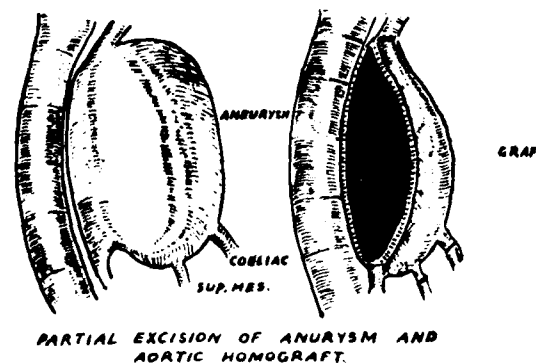


Fig. 9

Excision of aneurysm of abdominal aorta involving both coeliac and superior mesenteric artery and replacement with a graft

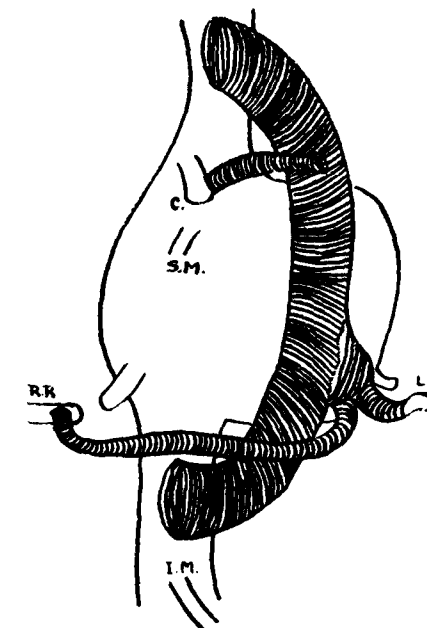


Fig. 11

Resection of Aneurysm of abdominal aorta involving both renal arteries, coeliac and superior mesenteric arteries. Diagram shows the knitted dacron graft sutured to both renals coeliac and aorta.

J. J., male, 30, came for pain in the epigastrium and left side back for 8 months. Examination revealed a pulsatile lump in the epigastrium $3\frac{1}{2} \times 3$ ", systolic murmur on the lump. B. P. upper extremity 110/75 mm. Hg. and lower extremity 125/85 mm. Hg., Kahn test strongly positive. Aortography - a saccular aneurysm of aorta at the level of T-12, L1, L2. (Fig. 12). The left renal artery not visualised. Under moderate hypothermia, thoraco-laparotomy was performed through the 7th rib bed. Diaphragm was divided and splenectomy done to expose the aneurysm which extended from a little above the diaphragm up to the renal arteries, both being involved within the aneurysmal sac. The left renal artery was small and obliterated. The aneurysmal sac on the side from which no important arteries were arising was clamped longitudinally by two long atraugrip clamps. The aneurysmal sac opened, thrombectomy done. Aneurysmal sac partially excised. The aorta was sutured by two sets of interrupted and one layer of continuous suture. Post-operatively the patient developed severe pulmonary infection and signs of hepatic coma from which he did not recover, and expired on the 15th post-operative day. The autopsy revealed an intact suture line and no obliteration of any of the large branches arising from the aneurysm. There were multiple abscesses in the lung and liver.

Three cases of leaking aneurysms of aorta have been operated by us, one was in the thoraco-abdominal aorta and two in the abdominal aorta. In two, the tear in the aneurysmal sac was sutured and in one, partial excision of the aneurysm and suture repair of aorta was done. The condition of all these cases was very low and they died soon after the operation.

We have had no case of dissecting aneurysm treated surgically in this series.

The thoracic aneurysm presents a different problem. Out of all the cases of thoracic aneurysms which were treated by us, the reconstructive procedure was used in 7. In one case, a technique which may be called exo-aneurysmorrhaphy (Case 10) was employed. This consisted of bilateral anterior thoracotomy. Placement of mattress sutures through the aneurysmal sac and tying them to obliterate the sac. (Fig. 13). Excision of saccular aneurysm was performed in 3, aortic arch replacement in 1, and excision of descending thoracic aneurysm and replacement with graft was performed in 2 cases.

Case Report 10.—Aneurysm of Ascending aorta. Exo-aneurysmorrhaphy.

H. B., male, 30, came for pain in the chest and exertional dyspnoea for two months. Examination revealed pulsatile swelling on the chest in the third and fourth intercostal spaces. Systolic and diastolic murmur in the third left space. B.P. - 114/64 mm. Hg., X-ray of the chest - aneurysm of the ascending aorta eroding the sternum. Bilateral anterior thoracotomy through the 4th rib bed and sternum - splitting was done to expose the saccular aneurysm of the ascending aorta firmly adherent to the surroundings. Exo-aneurysmorrhaphy was done to obliterate the proximal half of the aneurysmal sac. Post-operatively the pulsations of the aneurysm became less prominent. On 20th post-operative day patient suddenly expired due to the rupture of the aneurysm.

Case Report 11.—Saccular aneurysm of arch of aorta. Excision of aneurysm.

L. P., a Hindu male, aged 37 years, was admitted for cough with expectoration for 4 years and hoarseness of voice for 4 months. He also complained of exertional dyspnoea. He gave history of syphilis fifteen years ago. Examination of the cardiovascular system revealed that all the arterial pulsations were equal and normal. The blood pressure in the right arm - 110/80, left arm 100/76, right leg 138/80, left leg 126/74 mm. Hg. Tracheal tug was present. Systolic murmur was heard in the aortic area. X-ray chest revealed a globular shadow above the aortic arch. Intravenous angio-aortogram revealed a saccular aneurysm of the arch of aorta (Fig. 14). Blood serology was negative. The patient was hypothermised (31°C). Bilateral thoracotomy was performed through the 4th interspace on both the sides, and transverse splitting of sternum. A saccular aneurysm $3" \times 3" \times 2\frac{1}{2}"$ arising from the anterior aspect of the aortic arch at its junction with the ascending aorta was present. Loops were placed round the superior and inferior vena cava. The aneurysm was gradually dissected from its surrounding. Anteriorly, the aneurysm was adherent to the sternum and had to be mobilised by sharp dissection during short intervals of inflow occlusion. After completion of the dissection of the aneurysm all around, an atraugrip clamp was placed on the narrow neck of the saccular aneurysm which was then excised. The aorta was then sutured in three layers, two layers of interrupted mattress sutures and one layer of continuous suture (Fig. 15). The patient has made a complete recovery. The follow up after 6 months - patient is completely asymptomatic. The post-operative intravenous angio-aortogram shows normal appearance of aortic arch (Fig. 16).



Fig. 12

Saccular aneurysm of the abdominal aorta. Partial excision of the aneurysm and suture repair of the aorta was performed.

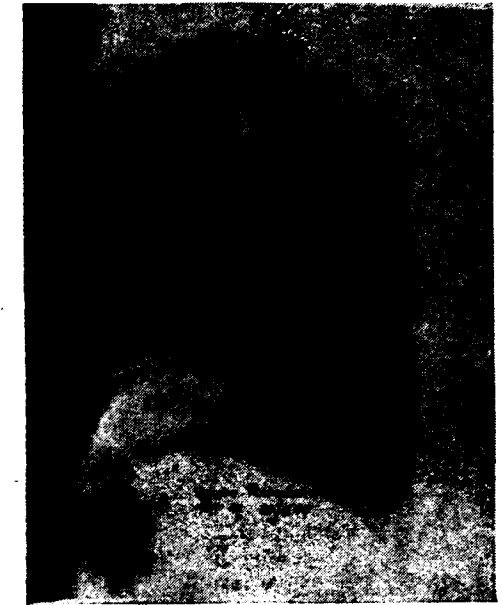


Fig. 14

Intravenous angio aortogram saccular aneurysm of arch of the aorta.

Case Report 12.—Aneurysm of descending thoracic aorta. Partial excision and aortic bypass.

G. F. M., a Muslim aged 55 years was admitted for pain in the back for one year and the pulsatile swelling left side back for 8 months. He complained

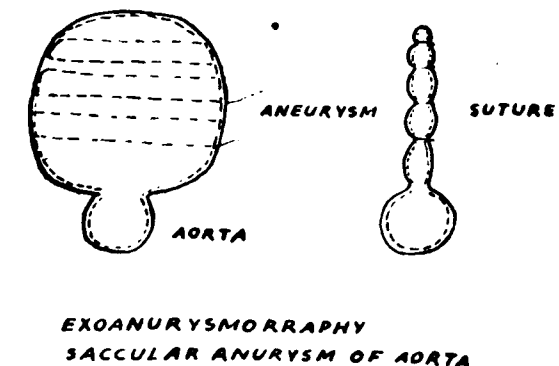


Fig. 13

The technique of exo aneurysmorrhaphy for saccular aneurysms.

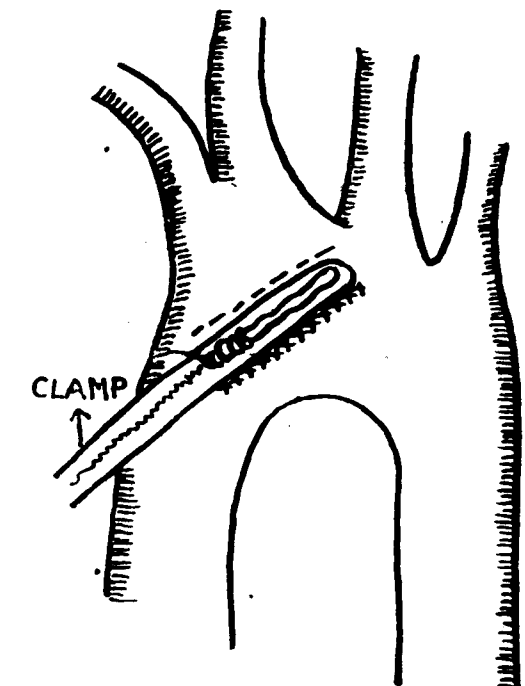


Fig. 15

Excision of saccular aneurysm of arch of the aorta and suturing. Note the atraugrip clamp placed at the neck of the aneurysm.



Fig. 16

Post operative intravenous angio aortogram. Note the normal contour of the aortic arch.

of exertional dyspnoea for one month prior to his admission into the hospital. He gave a history of having suffered from venereal disease 13 years ago. Examination revealed a pulsatile swelling $4'' \times 3''$ overlying 8th, 9th, and 10th ribs in the left infra-scapular region. The blood pressure in both arms was 140/40 mm. Hg. Systolic and diastolic murmur could be heard in the aortic area. X-ray of the chest revealed erosion of the 8th, 9th, and 10th thoracic vertebrae and fracture of 10th rib. Aortogram showed a saccular aneurysm of the descending thoracic aorta. The patient was hypothermised (31°C) and chest was entered through the 5th rib bed. The aneurysm was found to be arising from the lower portion of the descending thoracic aorta. The aneurysm measured 6 inches vertically and 6 inches transversely. The aneurysm had dissected into the chest wall posteriorly. A knitted dacron graft was sutured to the descending thoracic aorta about $1\frac{1}{2}''$ proximal to the aneurysm and the other end to the abdominal aorta one inch distal to the aneurysmal sac (Fig. 17). After establishing the bypass the aorta just proximal and distal to the aneurysm was closed with a running suture. Partial aneurysmectomy was then performed and the remaining sac was

obliterated with the help of stout mattress sutures. The patient expired one month after the operation, following a bout of haemoptysis. The autopsy revealed the intact dacron graft and aneurysm of the aorta opening in the left bronchus.

Cellophane wrapping was done for 7 cases - 4 for abdominal aneurysms, 2 for aneurysms of arch of aorta, and 1 for aneurysm of ascending aorta. The results were, on the whole, highly unsatisfactory, the aneurysm rupturing within 1-2 years. However, in one case (Case 13) where cellophane wrapping was done for saccular aneurysm of ascending aorta in 1955, the patient is living and has no symptoms except exertional dyspnoea due to aortic incompetence.

Case Report 13.—Aneurysm of ascending aorta. Cellophane wrapping.

J. D., male, 40, admitted for pain in the right side of chest and exertional dyspnoea. Examination revealed dullness on right 4th, 5th, and 6th intercostal spaces anteriorly. Diastolic murmur was

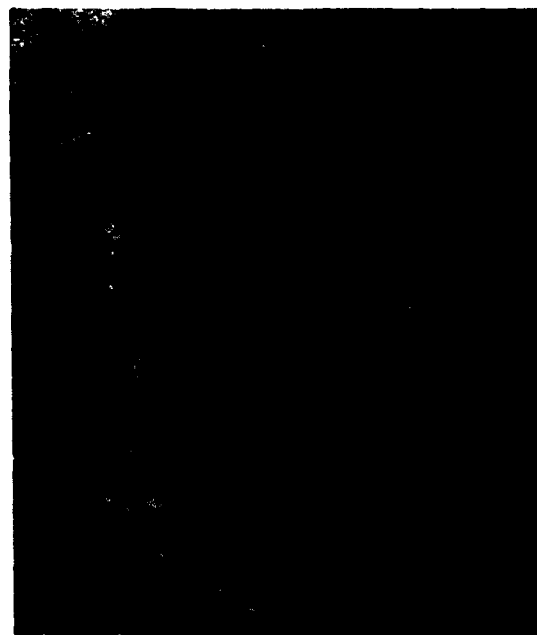


Fig. 17

Dacron bypass graft and partial excision for saccular aneurysm of descending thoracic aorta.

heard in aortic area. Kahn test was strongly positive. X-ray of chest - saccular aneurysm of ascending aorta. Exploratory thoracotomy was done. Large saccular aneurysm of ascending aorta was exposed and 8 sheets of cellophane wrapped round it. Follow up after six years - X-ray chest - size of aneurysm is more or less the same, a rim of cellophane can be seen around the aneurysm (Fig. 18).

Creation of arteriovenous fistula distal to an aneurysm brings about certain amount of reduction in the size of the aneurysm and temporary alleviation of pain. This method was used in two abdominal aneurysms for which definitive surgery was not possible.

Case Report 14.—Aneurysm of abdominal aorta. Cellophane wrapping and creation of arteriovenous fistula-left common iliac artery and vein.

R.M.S. 35, was admitted for abdominal lump and pain in the abdomen. Examination revealed huge lump in the epigastrium, right and left hypochondrium, umbilical and left lumbar region. On exploration there was a large saccular aneurysm of the abdominal aorta which had involved coeliac axis, superior mesenteric and both renal arteries. The aneurysm was inseparably adherent to surrounding structures. As any definitive surgery was not possible, an arteriovenous fistula between left common iliac artery and vein was made. Size of the stoma was about 6-7 mm. Eight sheets of cellophane were wrapped around the abdominal aneurysm. During post-operative period the size of the aneurysm had diminished and the patient was more comfortable. Four months after the operation, patient suddenly expired at home, probably due to rupture of the aneurysm.

For treatment of certain cases of congenital idiocy, arteriovenous shunt between common carotid and jugular vein was done on six occasions. Though no definite opinion regarding the value of this operation can be given in the light of our small experience, we feel that the results were far from encouraging. In fact, on two occasions, A.V. shunts thus created were closed and the artery and vein reconstructed, as no improvement occurred due to this operation.

Peripheral Artery Aneurysm.—Thirteen cases of peripheral artery aneurysms have been operated by us. Out of these, 6 were of popliteal artery, 4 of innominate artery, 1 of external iliac, 1 in subclavian artery and 1 in anterior tibial artery. The various reconstructive measures used for their treatment were excision and grafting (Case 15), excision

and suture repair of artery (Case 16), reconstructive endoaneurysmorrhaphy (Case 18), obliterative endoaneurysmorrhaphy (Case 17), proximal and distal ligation, etc. Out of 6 cases of popliteal aneurysms, homografting was done in 2, partial aneurysmectomy in 2, complete aneurysmectomy in 1, obliterative endoaneurysmorrhaphy in 1 case. The subclavian artery aneurysm was excised and replaced with a tubular dacron graft $3\frac{1}{2}''$ in length, successfully.

Case Report 15.—Aneurysm of popliteal artery. Excision of aneurysm and replacement with graft.

P., male, 77 years, was admitted for swelling in the right popliteal fossa - 1 year, and intermittent claudication - 6 months. Examination revealed a pulsatile lump in the right popliteal fossa - $4'' \times 3\frac{1}{2}''$. The dorsalis pedis, posterior tibial on the right side - not felt. Blood serology - negative. Arteriogram - popliteal aneurysm with a large clot. (Fig. 19). A long linear incision was taken on the popliteal fossa. The popliteal artery above the aneurysm was dissected and a loop was passed round it. The aneurysmal sac - gradually mobilised from the surrounding structure. The aneurysm was



Fig. 18

Skiagram of chest showing aneurysm of ascending aorta. Note the rim of fibrosis caused by reactive cellophane.

about 3½" long and 3" broad. The popliteal artery - clamped with a bulldog clamp and cut just proximal to the aneurysm so as to preserve the large collateral branch. The sac - completely excised, the distal stump of the popliteal artery identified. The arterial wall quite healthy. A graft 3½" long and ¼" diameter used. Continuous five zero silk suture was used. Post-operatively the distal arterial pulsations have returned. Patient does not complain of intermittent claudication any more. Post operative arteriogram shows normally functioning graft (Fig. 20).

Case Report 16.—Saccular aneurysm of popliteal artery. Excision of aneurysm and suture repair of popliteal artery.

D. S., male, 21 years, came to us for swelling in the right popliteal region - 1 year, and multiple bony swellings since birth (Fig. 21). Examination revealed multiple bony exostosis in connection with humerus, radius, tibia and femur, etc. Pulsatile lump in the right popliteal region. The right posterior tibial, dorsalis pedis feeble. Blood Kahn - negative. X-ray of the bones - multiple bony exostosis. X-ray of the chest - cystic disease of lung. I.V. Pyelography - cystic disease of kidney. The aneurysmal sac explored and then incised to evacuate blood clots. The saccular aneurysm was completely excised and the lateral tear in the popliteal artery was sutured. The osteoma of the tibia was excised. Post-operatively the distal pulsations remained adequate. Patient has done well.

Case Report 17.—Aneurysm of popliteal artery. Obliterative Endoaneurysmorrhaphy.

M. M., male 53 years, was admitted for swelling in the right popliteal region - 4 months, which was incised being mistaken for an abscess. Examination revealed a firm swelling in the popliteal region with signs of inflammation. The distal pulsations were feeble. The aneurysm was exposed, the clots were evacuated and the sac partially excised. Obliterative endoaneurysmorrhaphy was carried out. Follow up after 4 years - posterior tibial dorsalis pedis pulsations felt but are feeble. No claudication in that limb.

Case Report 18.—Aneurysm of common external iliac and femoral artery. Restorative endoaneurysmorrhaphy.

Male, 55 years, came to us for swelling right side, lower abdomen and right upper thigh, and pain in the abdomen. Blood Kahn test strongly positive. Fusiform aneurysm of common external iliac and

femoral artery were exposed. It had ruptured causing a retroperitoneal haematoma. Restorative endoaneurysmorrhaphy was done. Patient has done well.

So far, four cases of innominate aneurysms have been operated on by us. In three cases, nothing was done surgically after exploration. In one case, the aneurysm was occluded by proximal and distal ligation.

Case Report 19.—Aneurysm of innominate artery. Occlusion of aneurysm by proximal and distal ligation of aneurysm.

A. A., male, 55 years, came to us for swelling in the neck and exertional dyspnoea - 3 months. Examination revealed a pulsatile lump in the right supraclavicular region. A systolic thrill was palpable on the lump. Right radial pulse was feeble. Systolic and diastolic murmur was heard all over the precordium. B.P. - right arm - 120/60 mm. Hg., left arm 180/60 mm. Hg. Blood Kahn - positive. Aortogram - aneurysm of the innominate artery also involving the proximal part of right subclavian and right common carotid. An anterior thoracotomy through right 3rd interspace was followed by splitting the sternum vertically. A fusiform aneurysm of innominate artery exposed. An atheromatous plaque could be felt at the base of aneurysm. The innominate aneurysm was dissected all round and strong ligatures were passed round the aneurysm and gradually tightened so that the aneurysmal sac was completely occluded (Fig. 22). The distal ligation was put in such a way that the circulation between right subclavian and the right common carotid was maintained. Post-operatively the pulsatile swelling in the neck was markedly diminished in size. On screening, the pulsatile lump in the region of innominate aneurysm was no more seen. The patient had an uneventful recovery.

Embolism

Embolitic obliteration of the arteries is not too uncommon an incident in practice. It is our opinion, however, that most of these cases are brought too late to the surgeon, far too late for any definite surgery. We operated on 10 cases. The sites of obstruction were as follows:

1. Aortic bifurcation (4 cases).
2. Common carotid (2 cases).
3. Subclavian artery (1 case).
4. Common iliac (1 case).
5. Femoral artery (2 cases).



Fig. 19
Arteriogram showing the aneurysm of popliteal artery.



Fig. 20
Post operative femoral arteriogram. The arterial homograft used to replace the popliteal aneurysm is seen.

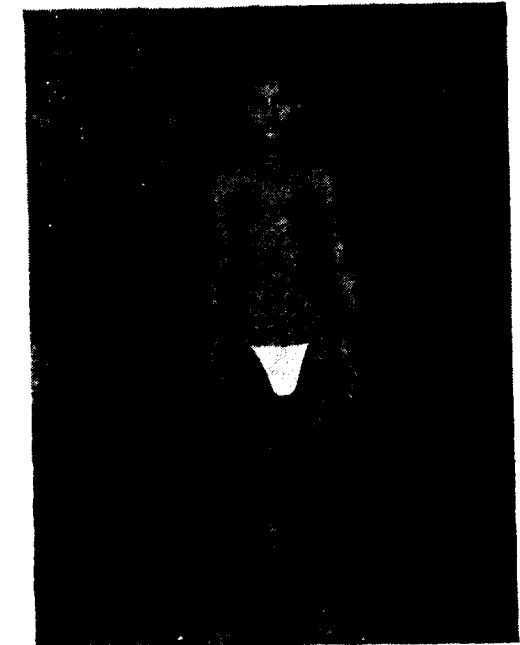


Fig. 21
Clinical photograph of a case of multiple exostosis of bones and dwarfism. Note the aneurysm of the right popliteal artery. The same patient had cystic diseases of the lungs and kidneys.

Case Report 20.—Saddle embolism of aorta. Embolectomy.

Female, 18 years, was brought for acute pain in the right leg and abdomen - 8 hours. Examination revealed that both femoral pulsations were absent and both lower limbs were cold. Abdominal aortic pulsations felt only in the upper part. Examination of cardiovascular system revealed signs of mitral stenosis. Exploratory laparotomy was performed about 12 hours after the patient started getting pain.

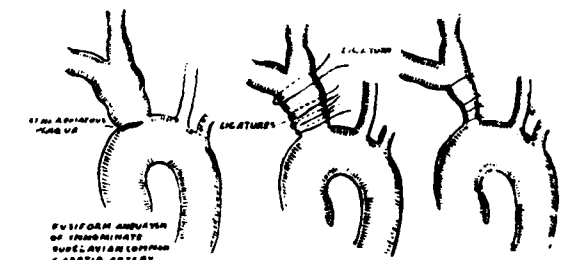


Fig. 22
Occlusion of innominate artery aneurysm by multiple ligation.

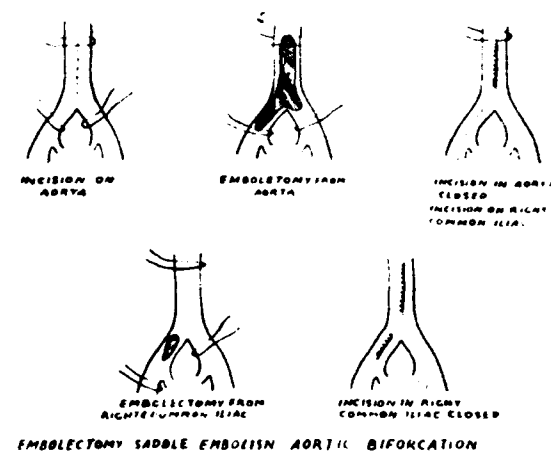


Fig- 23

Technique of embolectomy for saddle embolism of aorta.

The aortic bifurcation was exposed transperitoneally. A firm mass was felt in the aorta extending 2" above the aortic bifurcation. Through an incision over the aorta the embolus was removed. The remaining embolus was removed by an incision over the right common iliac (Fig. 23). Pulsations returned in the right common iliac artery. Post-operatively anticoagulants were exhibited, the extremities remained cold, the distal pulsations never returned. The patient developed gas gangrene of toes. The condition of the patient gradually deteriorated and she expired one month after the operation.

Case Report 21.—Saddle embolism of aorta, Embolectomy.

N. B., male, 21 years, admitted for intermittent claudication. Examination revealed that both femoral pulsations were absent. B. P. in lower extremity was not recordable. Systolic murmur was heard all over the precordium. Angiography showed a block at the aortic bifurcation. Aortic bifurcation was exposed transperitoneally. Pulsation in distal aorta both iliacs were absent. After applying clamps on aorta and common iliacs, the aorta was incised and embolus milked out. Post-operatively pulsations of femorals returned and the patient has done well. He no more complains of claudication.

Subsequently, we have treated two more cases of saddle embolism, one in a female child suffering from bacterial endocarditis and another in a young woman with mitral stenosis. Embolectomy was performed in both with complete recovery.

In this series, peripheral embolism occurred in 6 cases - 1 in the subclavian artery, 1 in common iliac and 2 in carotid arteries and 2 in femoral arteries.

Case Report 22.—Carotid Embolism. Carotid Thrombo-embolectomy.

T. R., male 45 years, referred to us for sudden weakness of right arm, leg and aphasia - 7 days duration. Examination revealed right sided hemiparesis and infranuclear type of facial palsy. Carotid pulsation left side was feeble. Bifurcation of common carotid was exposed, loops passed round common, internal and external carotid and clamps applied. Through a small incision on the common and internal carotid, the embolus from the common and internal carotid was removed (Fig. 24). Artery sutured (Fig. 25). Post-operatively there was a definite neurological improvement.

Thrombosis

Thrombotic occlusion of the arterial tree was subject to reconstructive surgery in 20 cases. In 5 more cases of thrombotic occlusion, nothing could be done surgically for the occlusive disease of aorta and its branches. The cases have been arbitrarily divided as follows:—Primary thrombosis (no cause could be detected), thrombosis in association with atheroma, thrombosis in association with arterial inflammation and

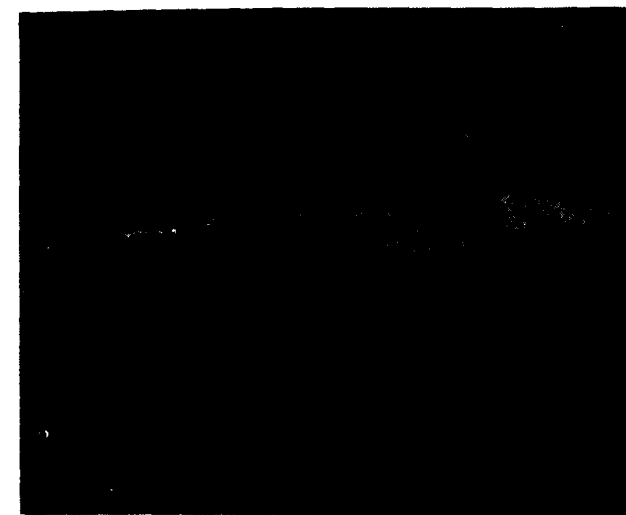


Fig. 24

Specimen of a thrombus removed from common internal and external carotid arteries.

collagen disorders - Takayasu's disease. In this group are also included 2 cases of aortic narrowing which were referred to us with the diagnosis of coarctation of aorta. Thrombectomy was done in 1 case. Thromboendarterectomy was performed in 8 cases, vascular by-pass with grafting in eleven cases, and thromboembolectomy and dacron patch grafting was done in one.

Primary Thrombosis of Thrombo-Embolism

Case Report 23.—Primary thrombosis of iliac arteries, Thrombectomy.

S. L., male 30 years, was admitted for severe pain in the right thigh for 8 hours. Examination revealed that right femoral pulsations and the distal pulsations were absent. Right lower limb was cold. Aortography revealed a block in the right common iliac.

Thrombectomy from common internal and external iliacs was done. Through an incision on femoral artery the remaining clot was evacuated. The artery was washed with heparin solution and then sutured. On releasing the clamps good pulsations returned in the femoral artery. Anticoagulants were exhibited post-operatively. The right lower limb remained cold and the distal pulsations were absent. In the post-operative period patient started getting haematuria, gradually the urine output diminished

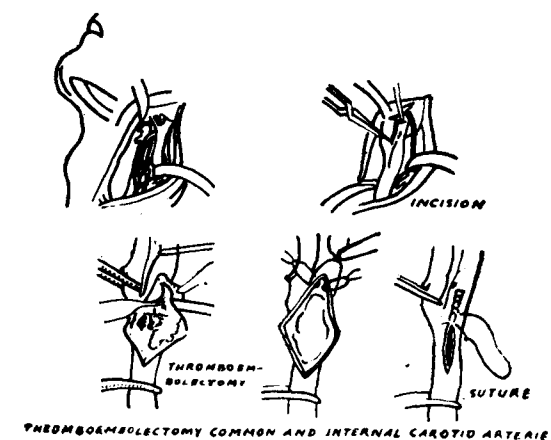


Fig. 25

The technique of thrombo-embolectomy from internal, common carotid arteries.

claudication in the lower extremity, and smoking for a long time.

Case Report 21.—Carotid artery thrombosis. Thromboendarterectomy and patch graft.

P. B., a Christian male, aged 35 years, was seen for sudden hemiparesis of left side of 3 days duration. There were no premonitory symptoms. There was transient loss of consciousness. There was a history of similar attack of hemiparesis 8 months ago followed by complete recovery. Examination revealed a well built and nourished male. Right carotid pulsations were feeble. Systolic bruit could be heard on the carotid artery. B. P. - arm was 120/80 mm. Hg. Examination of higher functions - dysarthria. He had a supranuclear type of facial palsy on left side. Flaccid hemiparesis and hemianaesthesia were present on left side. Left-sided tendon jerks were exaggerated. Planter reflex was present on left side. In order to confirm the diagnosis of carotid artery insufficiency, carotid angiogram was performed which revealed right internal carotid artery block. Under general anaesthesia the right common internal and external carotid arteries were exposed through a longitudinal incision on the neck. A linear incision was made on the common carotid and internal carotid artery. A polyethylene tube of 3.5 mm. internal diameter was passed through the incision proximally into the common carotid and distally into the internal carotid as a temporary shunt, in order to maintain the cerebral circulation. The thrombus from the internal carotid was removed. A dacron patch graft was sutured to the incision in the carotid artery. Post-operatively patient showed significant improvement as regards his mental state, though the hemiplegia was unaffected.

Case Report 25.—Left common carotid, left subclavian thrombosis. Thromboendarterectomy.

Z. A., male, 35 years, admitted for right sided hemiplegia and aphasia - 13 days. Examination revealed absent carotid and brachial pulse on the left side. B. P. in right arm 140/90 mm. Hg., aortogram revealed a block in the left common carotid half an inch from its origin and a block in the left subclavian artery also. Through an oblique incision in the neck, the common internal and external carotids were exposed. Through a small incision in the common carotid, a clot was squeezed out of the lumen. A scoop was passed in the proximal part of the common carotid and moved up and down, small fragments of clot in the proximal artery came out along with gush of blood from the aorta. Through another incision on common carotid near

its bifurcation, thromboendarterectomy from internal and external iliac was done till retrograde arterial flow was established. The incisions were sutured with arterial silk. Good pulsations returned to internal carotid.

Case Report 26.—Renal artery stenosis - Renal hypertension. Thromboendarterectomy and aortorenal bypass.

J. D., a Hindu male, aged 50 years, was admitted for severe headache in temporal region of 1 year duration. Examination revealed that his blood pressure was 200/130 mm. Hg. Intravenous pyelogram - delayed excretion and poor concentration of dye in right kidney. Lumbar aortogram - stenosis of right renal artery and post-stenotic dilatation (Fig. 26). Exploratory laparotomy was performed through a midline incision. Aorta was exposed at the level of the renal artery. The left renal artery and kidney were normal. A small atheromatous plaque could be felt within the right renal artery. Through a small incision on the right renal artery the atheromatous plaque could be removed only partially. A tubular knitted dacron graft 2" in length was anastomosed to the right renal artery and abdominal aorta. The graft was found to function well and renal artery

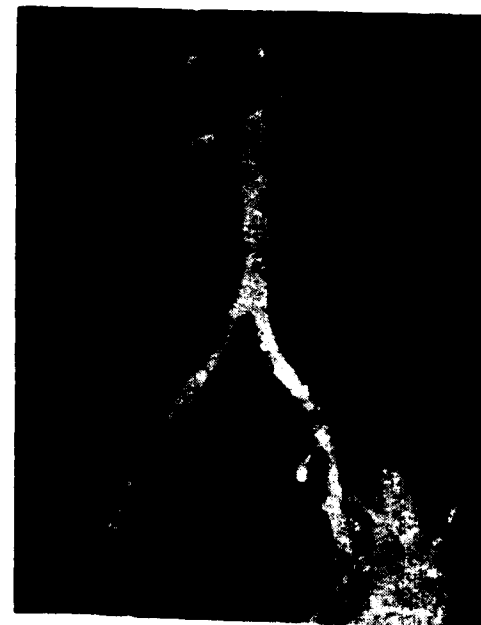


Fig. 26

Aortogram - note the stenosis of the right renal artery with a post-stenotic dilatation (a case of renal hypertension).

pulsations were good. Post-operatively there has been no notable fall in blood pressure even after 3 months of follow up.

Case Report 27.—External iliac femoral block. Thromboendarterectomy.

D. B., male, 22 years, came to us for pain in the left leg, and intermittent claudication - 6 months. Examination revealed wasting of left leg. Femoral pulsations were absent. B. P. upper extremity 110/60 mm. Hg. left lower extremity - not recordable. Blood Kahn test - negative. Lumbar aortography - left external iliac block. Exploration revealed that the distal part of external iliac, femoral artery up to its entry in femoral canal was non-pulsatile, thickened and obliterated with thrombus. Clamps were applied proximal and distal to the obliterated segment. Through a longitudinal incision on femoral, the thrombus along with intima and part of media was peeled out. A probe was manipulated to confirm the patency of artery distally. Artery was flushed with heparin solution and then closed (Fig. 27). Good pulsations were felt in the artery. Post-operatively the femoral pulsations were good but distal pulsations were not felt. The limb remained warm. Claudication was less marked.

In four more cases where thrombo-endarterectomy was done for thrombosis of one of the limb vessels (Fig. 28) the distal pulsations returned in only 2 cases. The relief from claudication was only partial.

Case Report 28.—Stenosing aortitis, subclavian artery thrombosis, narrowing carotid artery. Thromboendarterectomy - subclavian carotid brachial bypass.

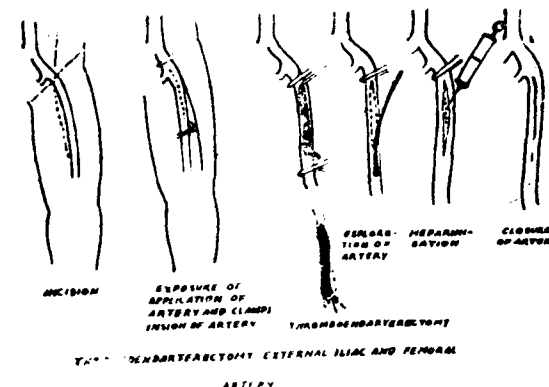


Fig. 27

The technique of thrombo-endarterectomy of external iliac and femoral artery.

I. N., female, 19 years, was admitted for pain left side chest and tingling numbness left arm for 1 year. Intermittent claudication - 8 months. Giddiness - 6 months. Examination revealed that brachial and radial pulsations on left side were absent. Femoral pulsations on both sides were feeble. Abdominal aortic pulsations were not felt. The B. P. right arm 170/70 mm. Hg., left arm not recordable, right leg 85/65 mm. Hg., left leg 70/65 mm. Hg. Soft systolic murmur was heard on the back along the left scapular border. Fundoscopy - spontaneous arterial and venous pulsations. Blood serology - negative. X-ray chest - normal heart shadow, prominent aortic knob, and left margin of descending thoracic aorta was tucked in. There was no rib notching. Aortogram revealed tubular narrowing of aorta which commenced below the arch and ended just above the diaphragm (Fig. 29). The left subclavian artery was blocked. Retrograde brachial arteriogram revealed block in the second part of axillary artery (Fig. 30). Thoracotomy was performed through 7th rib bed. The occluded segment of aorta was exposed. There was a marked periaortitis. A thrombus about 3½" in length could be felt within the aorta. Soft systolic murmur was felt just distal to the occluded segment. Through a longitudinal



Fig. 28

Lumbar aortogram showing block in the right external iliac artery.



Fig. 29

Aortogram showing the narrowing of the descending aorta - a case of stenosing aortitis.

incision on the aorta, thromboembolectomy was performed. Aorta was sutured and the clamps were removed. The pulsations in distal aorta were good. The systolic thrill disappeared. Cervico-dorsal sympathectomy on left side was then performed. Post-operatively the B.P. right arm 160/80 mm. Hg., left not recordable, right leg 160/70 mm. Hg., left leg 150/70 mm. Hg. Four months later the patient came to us with cervical tuberculous lymphadenitis. She was treated with antituberculous drugs and corticoids. On follow up, after 1 year, she complained of intermittent claudication, giddiness and pain in the left arm. Examination revealed absent pulsation in the left upper extremity, feeble femoral pulsations on both sides, and systolic murmur in the epigastrium and root of the neck on left side. B.P. right arm 175/80 mm. Hg., left arm not recordable, right leg 85/65 mm. Hg., left leg 70/60 mm. Hg. Direct suprasternal aortogram revealed narrowing of the proximal part of the left common carotid artery, and of the descending thoracic aorta. In order to increase blood supply to the carotid and left brachial arteries, right subclavian to left common carotid to left brachial bypass was performed by using a knitted dacron graft (Fig. 31). A polyethylene tube 4 mm. in diameter was introduced within the lumen of the

left carotid to maintain cerebral circulation during the period of anastomosis. It was removed just prior to completion of the suture. The same graft was carried through an artificially created space in the left axilla and was sutured to the left brachial artery. Left radial pulsations are now well felt and the blood pressure in left arm is 120/80 mm. Hg. Patient no longer complains of giddiness or of pain in left arm.

Case Report 29.—Stenosing aortitis thoracic aorta. Excision of stenosed segment and grafting.

S. N. H., male, 19 years, was seen for tingling numbness in both lower limbs, intermittent claudication and exertional dyspnoea - 7 months. Examination revealed that abdominal aortic pulsations and both femoral pulsations were absent. B.P. upper extremity - 214/100 mm. Hg., lower extremity - not recordable. Systolic murmur was heard on left sternal border in second left interspace. X-ray chest - slight rib notching. E.C.G. - left ventricular hypertrophy. Left thoracotomy through 4th rib bed was done. No coarctation was found at the usual situation. Later, 7th rib was excised and in descending thoracic aorta 4" above the level of diaphragm there was a marked periaortitis and slightly narrow thickened portion of aorta. Thrill was felt just distal to this segment. Distal aortic pulsation very feeble. Large intercostal arteries establishing collateral circulation were seen. Aorta proximal and distal to this segment was quite healthy. This segment after excision, was 3" long and its lumen 2 mm. broad. This segment showed advanced thrombotic and degenerative changes of intima. Homograft 4" long was used to replace the excised aortic segment. Good pulsations returned in the distal aorta. Fall of 60 mm. B. P. in upper extremities was noted. Femoral pulsations were palpable post-operatively. B. P. lower limb was 130/80 mm. Hg.

Case Report 30.—Aortoiliac thrombosis—Left renal artery block. Nephrectomy.

H. D., male, 35 years, admitted for tingling, numbness in both lower extremities - 9 years. Exertional dyspnoea, headache, giddiness for 6 months. Examination revealed abdominal aortic pulsations were absent. Femoral pulsations were feeble. B. P. upper extremity 230/110 mm. Hg., lower extremity - 110/70 mm. Hg. Fundoscopy - early changes of hypertensive retinopathy. X-ray chest - left ventricular hypertrophy. E.C.G. - left ventricular strain. I. V. Pyelography - non-functioning kidney left side. Aortography - aortic block below the level of superior mesenteric (Fig. 32). Retrograde femoral arteriogram - block near the origin of common iliac (Fig. 33).

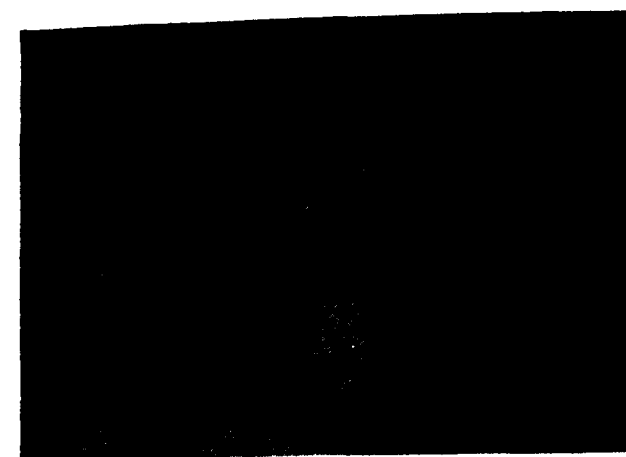


Fig. 30

Retrograde brachial arteriogram showing block in the axillary artery.

Under hypothermia-exploratory laparotomy was done. Marked narrowing of abdominal aorta below superior mesenteric. Absence of aortic pulsations and periaortitis. Similar changes were found in left common iliac, external iliacs. Left kidney - small. Because of the extensive nature of the occlusive process no vascular reconstruction was possible. Nephrectomy left side done. Marked fall of B. P. noted. Patient died suddenly on 10th post-operative day due to cerebral thrombosis. Autopsy-atherosclerotic narrowing and extensive thrombosis of abdominal aorta.

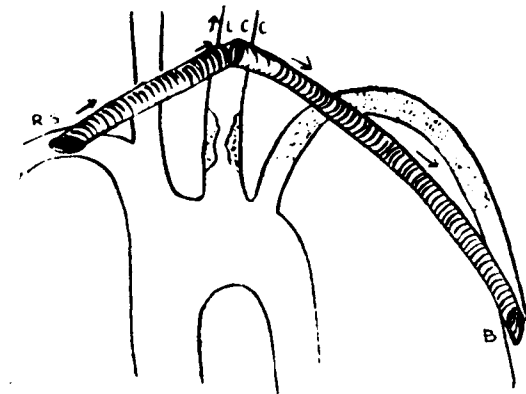


Fig. 31

Dacron bypass graft right sub-clavian - left common carotid - left brachial, for thrombosis of left subclavian and axillary artery and narrowing of left common carotid.



Fig. 32

Lumbar aortogram showing aortic block below the level of the superior mesenteric artery.



Fig. 33

Retrograde femoral arteriogram showing a block in the right common iliac artery.

In yet another case of similar nature in which there was aortic occlusion starting from just below the renals up to the aortic bifurcation thromboembolectomy was performed. Post-operatively there was a progressive renal shut down and autopsy revealed that the thrombotic process had extended into the renals. In our subsequent cases of aortic thrombosis, bifurcating type of aortic bypass was used in 5 cases. The upper end of the graft was sutured well above the occluded segment and the lower end is anastomosed to the femoral arteries. In one case, thrombosis occurred in the graft and the patient developed gangrene of both lower limbs. Rest of the cases did well. The distal pulsations of the limb are present and claudication has disappeared. In 5 cases tubular knitted dacron grafts were used to bypass the segmental block in the iliac arteries or femoral arteries. The results in all but 1 case were encouraging. It is felt that the patients who come well before the gangrenous changes have occurred in the limbs are the ones who benefit most. In those where gangrenous changes are present, invariably the distal vessels are also obliterated and vascular bypass procedure is not advisable. This occurred in about 8 cases where, after exploration no reconstructive procedure

was possible because of the extensive nature of the occlusive process.

Case Report 31.—Aortic thrombosis. Bilateral aorto-femoral bypass.

I. J., male, 49 years, was admitted for intermittent claudication for 5 years, backache for 3 years. He smoked 30 to 40 cigarettes per day. He gave a history of having suffered from syphilis 10 years ago. Examination revealed wasting of both lower limbs, left more than right. Femoral pulsations on left side were absent and right femoral pulsations were feeble. B.P. right arm - 138/70 mm. Hg., left arm - 140/70 mm. Hg., right and left leg - not recordable. Systolic bruit could be heard on abdomen just below the umbilicus. Aortogram revealed complete block of left common iliac artery. There was good retrograde feeling. The right common iliac was narrowed near its origin from aorta.

Femoral arteries were exposed through longitudinal incision on the thigh and were found to be patent but non-pulsatile on left side. Laparotomy was then performed through a longitudinal midline incision. The aortic bifurcation was exposed. The left common iliac was occluded due to a thrombus, the right



Fig. 34

Postoperative Lumbar Aortogram DeBakey Dacron Bifurcation graft bypass in place for obstruction at the bifurcation of the aorta.

common iliac was markedly narrowed and calcific. The abdominal aorta above the origin of inferior mesenteric was then exposed and atraumatic clamp was placed longitudinally so as to occlude it partially. A longitudinal incision was then made on this segment of the aorta. The proximal end of a bifurcation dacron graft was then sutured to the abdominal aorta with 3 zero over and over suture. The two ends of the bifurcation graft were sutured end to side to both femoral arteries by using 4 zero arterial silk (Fig. 34). The distal pulsations in both lower limbs are now

well felt, and B. P. is 130/70 mm. Hg. Patient is able to walk long distances without any claudication.

Summary

In this paper we have attempted to summarise our total experience of 106 cases of reconstructive surgery of the larger arteries, including the aorta. Case reports have been utilised to illustrate the various disease patterns and their surgical treatment.

REFERENCES

1. Bahnon, H. T.: Definitive Treatment of Saccular Aneurysm of the Aorta with Excision of the Sac and Aortic Suture, S. G. O. 96: 383, 1953
2. Carrel, A.: Proc. of Soc. for Exp. Biol. and Med. 7: 80, 1910.
3. Carrel, A.: Results of Transplantation of Blood Vessels, Organs and Limbs, J. A. M. A. 51: 1662, 1908.
4. Cordell, A. R., Wright, R. H., Johnston, R. R., Winston Salem, N. C.: Gastro-intestinal Haemorrhage After Abdominal Aortic Operations, Surgery 48: 997, 1960.
5. DeBakey, M. E., Cooley, D. A., Creech, O. L.: Aneurysm of the Aorta Treated by Resection. Analysis of Three Hundred Thirteen Cases, J. A. M. A. 163: 1439, 1957.
6. Lam, C. R., Aram, H. H.: Resection of the Descending Thoracic Aorta for Aneurysm, Ann. Surg. 134: 743, 1951.
7. Robb, C. G., Eastcott, H. H., Owen, K.: The Reconstruction of Arteries, Br. J. Surg. 43: 449, 1956.

—Received for publication on 30-6-1961.

TOTAL CARDIOPULMONARY BYPASS BY CONTROLLED CROSS CIRCULATION

BY

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Establishment of a simple, effective and safe method of total cardiopulmonary bypass for corrective intracardiac surgery is one of the goals that has motivated the experimental work in our laboratories. While we have been quite occupied, exploring the applicability of deep hypothermia and mechanical oxygenators for open heart surgery our attention was drawn towards the principle of biological oxygenation and being fascinated with certain of its obvious advantages we decided to further investigate this avenue of circulation bypass which has not received sufficient attention in recent years.

The reciprocal interchange of blood between two individuals can be done in many ways. The exchange of venous blood between two individuals is called cross transfusion. The transfer of arterial blood of one individual into the venous system of another and corresponding transfer of the blood from the arterial system of the latter to the venous system of the former could be rightly called cross arteriovenous transfusion. The reciprocal transfer of blood from the arterial system of one (Donor) to the arterial circulation of another (recipient) and from the veins of the latter to the venous system of the former is called cross circulation or donor circulation. When the exchange of blood between the donor and recipient is regulated by using a mechanical pump it is called controlled cross circulation or controlled donor circulation. In the series of experiments to follow the method

of controlled cross circulation has been employed to establish a total cardiopulmonary bypass so as to exclude the heart and lung of the recipient from circulation for varying periods and during this time the circulation of the recipient is supported by another intact animal donor whose arterial blood is exchanged for the venous blood of the recipient. Thus the heart and lung of the donor is taking over the responsibility of supporting the circulation and maintaining the oxygenation of the recipient in addition to his own.

Blum and Meigebow² (1950) were the first to employ the method of cross circulation experimentally for establishing cardiopulmonary bypass but their work was of a preliminary nature. Southworth and Pierce³ (1952), Glenn and Sewell⁴ (1953) published their report of experiments using cross circulation but their results have not been very contributive. Andreason and Watson¹ (1953), Warden et al⁵ (1954) reported their experimental work with controlled cross circulation for establishing cardiopulmonary bypass. They used mechanical pump for reciprocal transfer of blood and utilised small flow rates, as supported by their experimental work of azygos flow study. Later Lillehei⁶ (1955) reported his experience of clinical application of this method for direct vision intracardiac corrective surgery for various types of congenital malformations of heart.

The present study was undertaken in order to assess the efficiency of this method

when combined with cardioplegia in recipient dog, to get familiar with the technical aspect of this method, to study various physiological changes in both donor and recipient, and to make certain modifications in the original technique so as to make this method more practicable and safe for establishing a cardiopulmonary bypass for open heart surgery. In this paper a preliminary report of 35 animal experiments carried out in the Department of Surgery, K.E.M. Hospital, Bombay, is presented.

Apparatus

The apparatus consists of a constant perfusion Sigmamotor pump, a set of polyvenyl tubings, catheter and two reservoirs. One set of polyvenyl tubing carried the venous blood from the recipient to the donor and the other set carried the oxygenated arterial blood from the donor to the arterial system of the recipient (Fig. 1).

The constant perfusion Sigmamotor pump maintained an unidirectional flow in the circuit and adjusted exchange of blood across the two animals.

A venous reservoir was introduced in the circuit to receive the blood from the recipient's venous system. This reservoir was placed in a more dependant position and thus could maintain a constant free flow out of the caval system of the recipient, prevented a direct elevation of negative pressure in the caval system and acted as a bubble trap. The level of blood in the venous reservoir is an excellent indication of adequacy of flow through the venous circuit. Fall of the level indicates some obstruction to the caval catheters and calls for their readjustment or temporary slowing down of the venous flow rate.

Arterial reservoir has been introduced for the first time in these experiments. We



Fig. 1

Photograph showing the anaesthetised dogs (Donor and Recipient) and the apparatus used for controlled cross circulation.

feel that arterial reservoir is as essential as the venous reservoir because in addition to acting as an effective bubble trap, the level of blood within it gives the indication of adequacy of supply of arterial blood to the recipient. Any fall of the level indicates an obstruction to the arterial catheter in the donor or fall of blood pressure in the donor and calls for immediate readjustment of the arterial catheter in the donor or temporary slowing of the arterial flow rate till the blood level is well adjusted. In addition to subserving the functions already mentioned the venous and arterial reservoirs are useful for priming the circuit with blood which may be occasionally necessary.

The polyvinyl tube and the reservoirs were heat sterilised. The arterial and venous catheters were sterilised by immersing them in 1% Cetavlon solution for 24 hours. The entire circuit was filled with heparinised 5% dextrose solution before starting the perfusion.

Material

Healthy mongrel dogs weighing between 15 and 22 kg. were used as donors. Mongrel dogs weighing between 5 and 12 kg. were used as recipients. Four mongrel dogs were used as donors on more than one occasion. The blood of each set of donor and recipient dog was directly cross-matched before perfusion during the first 20 experiments. On no occasion mismatching of blood was encountered.

Anaesthesia

Both the donor and recipient dogs were accurately weighed before each experiment. Each dog was anaesthetised by injecting sodium thiopentone (25-40 mg. per kg. body weight) intravenously. Intratracheal tubes were passed and connected to respiratory pumps. Both the dogs were hyperventilated. During the period of cardiopulmonary

bypass the respiration of the recipient was stopped and the donor was supplied 100% oxygen through a respiratory bag under pressure. Five per cent dextrose was given intravenously to each animal as a supportive therapy.

Method

The flow rate of perfusion was calculated depending upon the weight of the recipient dog. Both the venous and arterial pumps were adjusted to deliver accurately the calculated amount of blood per minute. The oxygenated arterial blood of the donor was received through a polyethylene catheter introduced through its femoral artery into the abdominal aorta; blood of the donor was pumped into a catheter passed through the femoral artery into the abdominal aorta of recipient. Lateral thoracotomy through right 5th interspace was performed in the recipient. Vena azygos was ligated. Silk loops were passed round the superior and inferior vena cava near their entrance into the right atrium. The pericardium was incised longitudinally and retracted with the help of sutures.

In our initial 5 experiments a specially designed polyethylene catheter with multiple side holes near the tip and at a suitable distance from its tip was introduced through the jugular vein and directed through the innominate vein into the superior vena cava and thence through the right atrium into the inferior vena cava, in such a way that the tip of the catheter remained in the inferior vena cava and the lateral perforations remained in the superior vena cava. On pulling the loops placed round superior and inferior vena cava complete inflow occlusion could be brought about (Fig. 2). Just prior to starting the perfusion all connections were properly checked and both venous and arterial pumps were simultaneously started. In most of our

Fig. 2

The method of transjugular caval catheterisation.

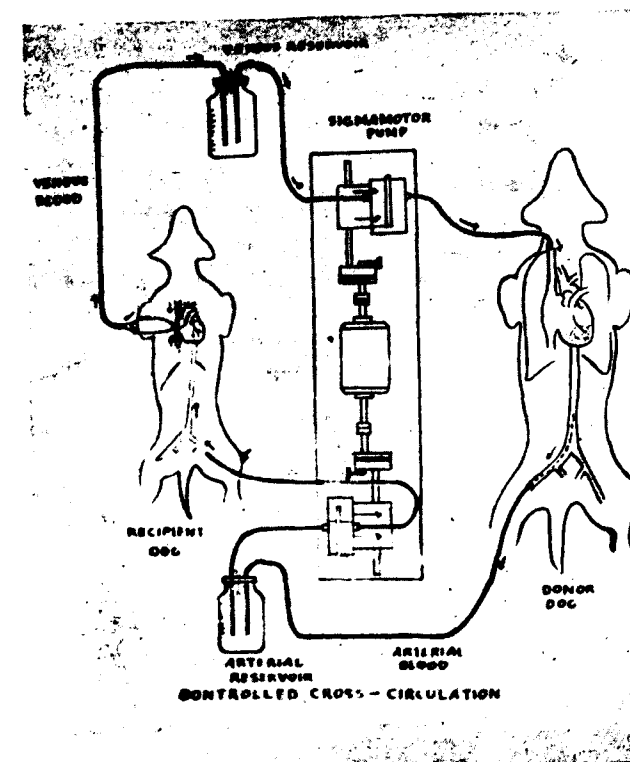
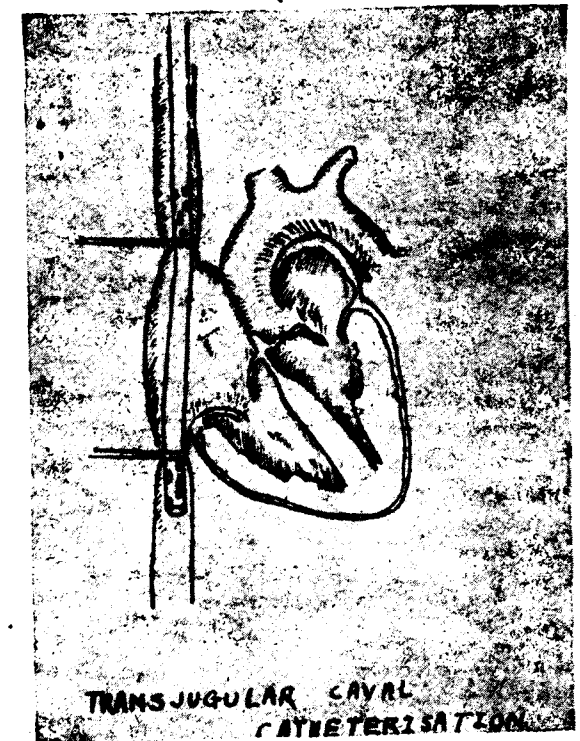


Fig. 3

Diagrammatic representation of the method of controlled cross circulation.

latter experiments direct transatrial cannulation of the vena cava (Fig. 3) was preferred as introduction of polyethylene catheter of suitable size though the jugular vein was technically difficult and flow of blood through these catheters was not free. The transatrial caval cannulation was technically simple and blood loss during such cannulation was insignificant and the flow of blood through the caval catheters was unobstructed.

Following different flow rates of perfusion were employed during the experimental work: (Table 1).

20-35 c.c./kg. body weight of recipient per minute.

40-55 c.c./kg. body weight of recipient per minute.

60-70 c.c./kg. body weight of recipient per minute.

75-100 c.c./kg. body weight of recipient per minute.

After varying periods of total cardiopulmonary bypass the loops round the

superior and inferior vena cava were gradually released and thus the recipient dogs were on partial perfusion for a short interval. Both the venous and arterial pumps were stopped and the caval catheters were withdrawn and atriotomy wound was closed.

Just prior to the cannulation both donor and recipient were each given 1 mg. heparin per kg. body weight as a single dose intravenously. Protamine sulfate 2 mg. per kg. body weight was given to the recipient at the end of the experiment. No protamine was given to the donor.

During the period of perfusion the maximum attention was given to the following technical details.

The arterial input from the donor should be exactly the same as venous return from the recipient. Provided that all the catheters were suitably placed and the pumps accurately adjusted there was no difficulty encountered in achieving the reciprocal exchange of blood. The arterial catheter in the donor should be multiperforated and

Table 1

Total Cardiopulmonary Bypass by Controlled Cross Circulation

No. of Experiment.	Flow rate c.c./kg./minute.	Period of perfusion in minutes.	Donor mortality.	Recipient mortality
6	20-35	10-20	Nil	4 Brain damage -- 3 Haemothorax -- 1
6	40-55	10-25	Nil	4 Brain damage -- 1 Haemothorax -- 1 Technical error -- 2 (Atrial tear pneumothorax)
7	60-70	10-30	1 (late death Cause?)	Nil
8	75-100	7-15	2 (shock Air embolism)	1 (air embolism)

should be placed well high in the abdominal aorta of the donor to assure a free flow of arterial blood. Once the pumps are started the levels of blood in the venous and arterial reservoirs are constantly monitored and attempt is made to maintain them at initial level. Occasional adjustment of caval catheters in the recipient, adjustment of arterial catheter in the donor and temporary alterations in the flow rates of blood was all that was necessary in majority of instances.

A graphic record of the different flow rates employed every minute throughout the perfusion was maintained by an assistant (Fig. 4). Any discrepancy in the venous and arterial exchange was noted and corrected prior to stopping the pump in order to achieve the exact reciprocal interchange between the two animals.

The circulatory state of the donor should be maintained at optimum level so that he bleeds freely in the recipient. Constant electrocardiographic control and frequent blood pressure records with a manometer of the donor were maintained to denote its circulatory state which remained at optimum level throughout the period of perfusion and no special measures except a slow 5% glucose intravenous drip was found necessary.

The oxygenation of the donor should be adequate so that both the donor and the recipient receives fully oxygenated blood at normal pH. Throughout the period of cross-circulation a great attention was given to supply 100% oxygen to the donor about 40 times a minute under pressure with the aid of a respiratory bag.

In order to precisely determine the adequate amount of arterial input so as to

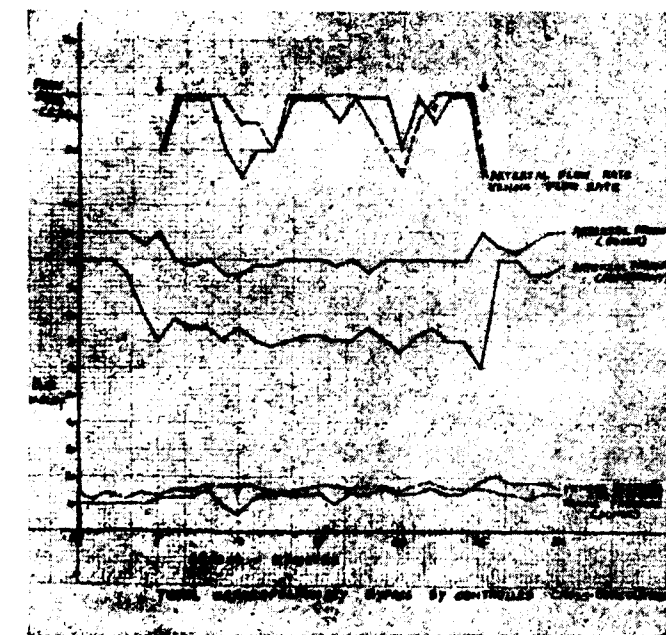


Fig. 4

A graph showing the arterial and venous flow of perfusion and mean arterial and venous pressures of donor and recipient dogs during controlled cross circulation.

maintain the recipient dog in a well balanced physiological state from which early recovery can be obtained, different flow rates as stated above were employed.

Post-operatively both the donor and the recipient dogs were accurately weighed to roughly assess the blood volume of the dog and to exclude any serious quantitative disproportion during reciprocal exchange of blood. In the present series no significant disproportion in the exchange of blood between the two animals was noted in any experiment except one.

In the last ten experiments after the inflow occlusion in the recipient the ascending aorta was clamped and a cardioplegic solution (25% potassium citrate diluted in blood) was injected into the proximal aorta to perfuse the coronaries and cardiac arrest varying from 10 to 30 minutes was brought about during which the heart remained flabby. At the end of which the clamp on the ascending aorta was released and in 3 to 7 minutes the normal cardiac rhythm

was established in all cases, later the dogs were taken off the perfusion (Table 2).

The following physiological and biochemical changes have been studied in both donor and recipient dogs prior to, during and after the period of cardiopulmonary bypass by cross circulation. Arterial and venous pressures and electrocardiogram were constantly recorded in both donor and recipient throughout the perfusion. Plasma haemoglobin level in both donor and recipient dogs was estimated after perfusion in order to estimate the hemolysis occurring during such a procedure. Blood oxygen content of the arterial blood of both the donors and recipient and the venous blood of recipient was estimated. Arterial blood pH of both donor and recipient prior to, during and after cross circulation was also estimated.

Recipient

The aortic and carotid artery pressures (Fig. 5) were recorded in the recipient

Table 2

Total Cardiopulmonary Bypass by Controlled Cross-Circulation (and Cardioplegia)
Average Flow Rates: 60-70 C.C./KG. Body Weight per Minute

Exp. No.	Weight of recipient Kg.	Wt. of donor Kg.	Total flow rate of blood/min.	Period of perfusion Min.	Cardioplegic (Min.)	Donor	Recipient.
26	8	17	480 c.c.	20	10	Survived	Survived
27	8	18	500 c.c.	25	16	Survived	Survived
28	7	15	490 c.c.	28	20	Survived	Survived
29	9	20	550 c.c.	20	13	Survived	Survived
30	10	20	600 c.c.	20	14	Survived	Died (shock)
31	8	18	500 c.c.	20	19	Survived	Died (late death)
32	7	16	490 c.c.	25	16	Survived	Survived
33	6.5	15	400 c.c.	32	22	Survived	Survived
34	7.5	18	450 c.c.	45	30	Died late death	Died brain damage
35	8	16	500 c.c.	25	18	Survived	Survived

dog during the perfusion using different flow rates. The carotid artery pressures were somewhat lower than the aortic pressures.

The venous pressure remained fairly constant during the different flow rates provided that the exchange of blood in the two animals was accurately controlled (Fig. 6).

The plasma haemoglobin estimation during the different flow rates was noted. It was found to be high (though not significantly) in those experiments where high flow rates were employed for prolonged period. Average plasma haemoglobin in majority of experiments was 50 to 70 mg.% (Table 3). The arterial pH did not show any significant change as long as the flow rates were above 50 c.c. per kg. per minute (Table 4). The arterial oxygenation throughout perfusion was excellent but the venous oxygen level showed progressive fall as the flow rates were lowered.

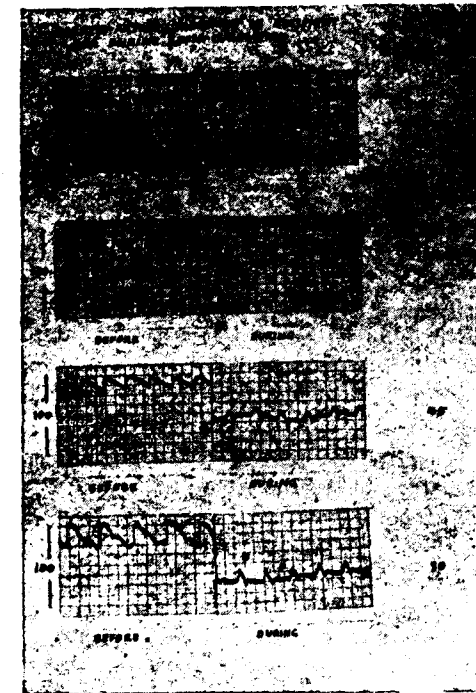


Fig. 5

Carotid artery pressure tracing in recipient dogs during total cardiopulmonary bypass by controlled cross circulation with different flow rates of perfusion.

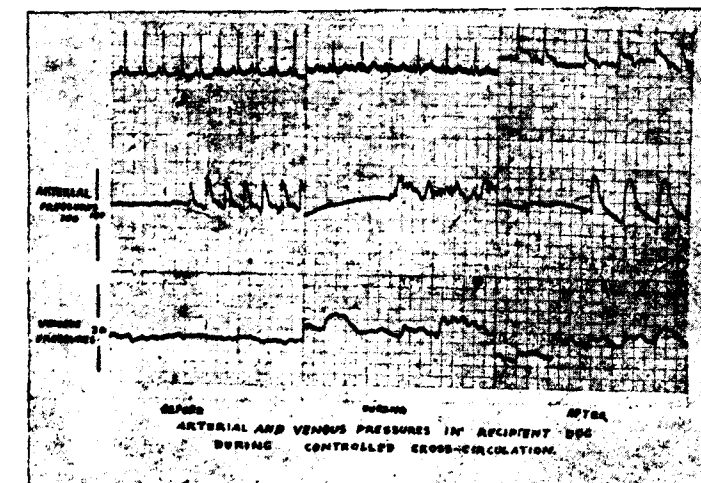


Fig. 6

Arterial and venous pressure tracing in the recipient dog during total cardiopulmonary bypass by controlled cross circulation.

Table 3*Total Cardiopulmonary bypass by controlled cross-circulation***HAEMOLYSIS**

Flow rate c.c./kg. body weight.	Plasma haemoglobin per cent.
20 to 25	— 35 to 50 mg.
40 to 55	— 50 to 60 mg.
60 to 70	— 50 to 80 mg.
75 to 100	— 80 to 100 mg.

Donor

During the present series of experiments four dogs were used as donors on more than one occasion. During one of the experiments after a period of 15 minutes of cardiopulmonary bypass the recipient dog died due to uncontrollable haemorrhage from the atriotomy wound. Another experiment was immediately carried out using the same donor and both the recipient and donor survived. The donor does not experience any net loss of blood or gain of blood during the perfusion as the pumps are set to return the same amount of venous blood as the arterial blood lost by the donor. The physiological changes in the donor have been of slight tachycardia and if at all a very minor fall of systolic blood pressure and significant fall in

diastolic pressure during high flow rates (Fig. 7). In majority of cases the animal could easily stand to the sudden alteration in the circulatory state which is equivalent to creation of arteriovenous fistula in the animal during the period of perfusion. After using high flow rates (above 70 c.c. per kg. body weight) however 5 donor dogs went into a state of shock out of which one succumbed (Table 5).

The venous pressure was moderately elevated during perfusion on particularly while using high flow rates.

Plasma haemoglobin estimation revealed insignificant amount of hemolysis in most of the donors. The maximum plasma haemoglobin was 100 mg. % in the experiment where high flow rates were used for prolonged period. In majority of experiment it varied between 30 and 70 mg. %.

Post-operative bleeding tendency was noted in no donor dog. Protamine sulfate was not found to be necessary in any case.

The arterial pH of the donor was not significantly lowered during the cross circulation and it was restored to normal soon after perfusion.

Table 4*Total Cardiopulmonary Bypass by controlled cross-circulation pH during Perfusion*

Flow rate c.c./kg. body weight of recipient.	Recipient			Donor			Average variation in pH of recipient during perfusion.	Average variation in pH of donor during perfusion
	B.P.	D.P.	A.P.	B.P.	D.P.	A.P.		
20 - 35 c.c.	7.35	7.15	7.33	7.36	7.15	7.35	0.15 to 0.25	0.12 to 0.20
40 - 55 c.c.	7.32	7.24	8.30	7.31	7.24	7.32	0.07 to 0.15	0.05 to 0.13
60 to 70 c.c.	7.30	7.24	7.29	7.32	7.24	7.30	0.05 to 0.12	0.03 to 0.10
75 - 100 c.c.	7.33	7.28	7.32	7.34	7.28	7.31	0.05 to 0.10	0.03 to 0.10

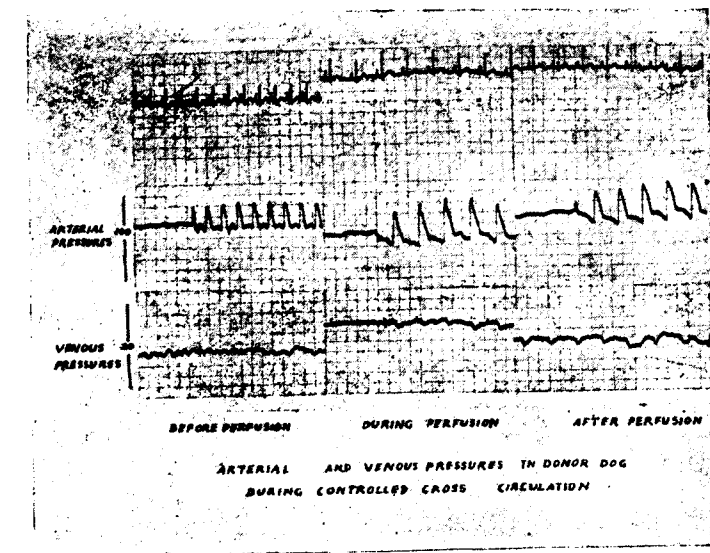
B.P. = before perfusion.

D.P. = during perfusion.

A.P. = after perfusion.

Table 5**Donor**

Flow rate/kg. body weight	Arterial pressure		Mean venous pressure mm. Hg.	Heart rate	Mortality	Complications
	Systolic mm. Hg.	Diastolic mm. Hg.				
75 - 100 c.c.	80 - 100	35 - 40	15 - 20	Tachycardia 20-30/min.	2	Shock - 4
60 - 70 c.c.	90 - 100	45 - 50	12 - 15	Tachycardia 10-20/min.	2	Shock - 1
40 - 55 c.c.	90 - 110	45 - 55	9 - 12	Tachycardia 10-15/min.	Nil	Nil
20 - 35 c.c.	90 - 110	50 - 60	9 - 12	No change. Tachycardia 5-10/min.	Nil	Nil

**Fig. 7**

Arterial and venous pressure tracing in the donor dog during controlled cross circulation.

Discussion

Though the nature of the experimental work carried out has been of a very preliminary nature, certain observations made have further enlightened us regarding the potentialities of this technique of circulatory bypass. The various technical details were very critically studied and modified in order to make this method technically simple, safe and effective. The study of physiological

changes in both recipients and donors in the present series of experiment using different perfusion flows show that the most ideal flow rate seems to be between 50 and 70 c.c. per kg. body weight of recipient per minute in order to maintain the recipient dog in a well balanced physiological state, to assure early recovery of cardiac rhythm and to prevent brain damage and acidosis during the period of bypass. During these flow rates

the arterial pressure was maintained between 70 and 80 mm. of Hg. The myocardium remained pink. The coronary A. V. difference was good (Table 6). The cardiac rhythm was slow, regular throughout the period of total bypass. With these flow rates recovery after chemical cardiac arrest was also rapid. During higher flow rates than these no particular advantages both regarding cardiac action or regarding recovery from anaesthesia were encountered. As the flow rates were diminished below 50 c.c. per minute kg. body weight the chances of the animal to recover after cardiopulmonary bypass became less and less. The arterial blood pressure was lowered, the cardiac action became poor with flow rates below 35 c.c. per kg. body weight per minute. Cardiac irregularities appeared. The coronary A. V. difference was poor. The recovery of heart after period of circulatory bypass was delayed and uncertain. With flow rates below 25 c.c. per kg. body weight the cardiac action was feeble and the heart became extremely irritable.

The biochemical changes during the period of cardiopulmonary bypass also

clearly show that in order to prevent acidosis in the recipient during bypass flow rates above 50 c.c. were found essential.

In 35 dogs total cardiopulmonary bypass was established so as to exclude the heart and lung of the recipient from circulation for varying periods by using controlled cross circulation. In the last 10 experiments cardiac arrest was induced for period varying from 10 to 30 minutes. Out of the 35 animals which were used as recipients there were 13 mortalities. Four occurred purely due to technical reasons (Table 7) (2 due to air embolism, one due to atrial tear and one due to pneumothorax following undetected lung tear). Five were due to brain damage. In 4 cases the flow rates were low and obviously inadequate. In one case where cardiopulmonary bypass of 45 minutes was established brain damage occurred, inspite of adequate flow rates. Post-operative bleeding tendency resulting into post-operative haemothorax was found to be the cause of death in 2 animals. In one case the animal went into irreversible shock probably due to inadequate reciprocal exchange of blood.

Table 6
Recipient

Flow rate c.c.	Colour of the myocardium	Coronary A. V. difference	Cardiac contraction	Cardiac irregularity	Cardiac irritability	Coronary sinus flow	Return of normal cardiac contractions	Return to consciousness of dogs	Systolic blood pressure mm. Hg.	Mean venous pressure mm. Hg.
20 - 35	Blue	Poor	Poor	Cupping of beats, nodal rhythm, paroxysmal, tachycardia, etc.	Markedly irritable	Insignificant	Delayed	Delayed	30 - 50	10 - 15
40 - 55	Purple	Poor	Fair	Extrasystoles etc.	Irritable	do.	Delayed	Delayed	50 - 65	10 - 18
60 - 70	Pink	Fair	Good	Nil	Nil	do.	Immediate	Soon	70 - 80	15 - 20
75-100	Very pink	Good	Good	Nil	Nil	Marked	Immediate	Soon	90-120	15 - 20

Table 7
Controlled Cross-Circulation

Recipient Dogs (35)	
Deaths - 13	
Operative and immediate post-operative	11
Late post-operative	2
Pneumothorax (technical fault)	1
Atrial tear (technical fault)	1
Arterial air embolism (technical fault)	2
Brain damage	5
Post-operative bleeding tendency (haemo- thorax)	2
Shock	1
Unknown cause (late death)	1
Donor Dogs (31)	
Deaths - 4	
Shock	2
Air embolism	1
Late death (cause?)	1

In the work carried out by various workers on cardiopulmonary bypass using cross circulation on cardioplegia was brought about. So far in the present series chemical cardioplegia of 10 to 30 minutes was brought by using 2.5% potassium citrate as the cardioplegic solution. During the period of recovery gentle massage was given to the heart. Within a period of 3 to 5 minutes the sinus rhythm was established in all cases. The perfusion flow used during these ten experiments was 60-70 c.c. per minute per kg. body weight. No deleterious effect of the cardioplegic solution was found on the donor's circulation.

In the 15 experiments where circulatory bypass varying from 15 to 45 minutes was established using flow rates between 60 and 70 c.c. per kg. body weight per minute, the recipient dogs started breathing spontaneously within an hour of the operation and became fully conscious within a few hours. There was only one recipient mortality during this series.

The physiological studies in the donor during the cardiopulmonary bypass reveal that the donor remains in a perfect circulatory state throughout as shown from the insignificant temporary alterations in the heart rate, blood pressure and venous pressure in these dogs. The pulse pressure is increased during the period of perfusion but it is instantaneously restored to normal as soon as the perfusion is stopped. Provided that the donors are healthy and they are sufficiently larger than the recipient dogs they could easily stand to the sudden circulatory change caused due to the additional responsibility of supporting another dogs circulation. Out of the 31 donors there were only 4 deaths (Table 7). In one dog death occurred due to massive air embolism and was due to purely a technical fault and was preventable. One dog died due to irreversible shock which followed perfusion and was obviously due to the very high perfusion rate used to support the circulation of another animal which was just a little smaller than the donor. In order to avoid this complication a choice of the donor of adequate weight is highly essential. The perfusion flow rate should be as low as possible in order to maintain the recipient in ideal physiological state. In the present series the donor dog weighed between 15 and 22 kg. and the recipient weighed between 6 and 12 kg. It was our observation that in order to make this procedure of circulatory bypass safe both for recipient and donor an adequate difference in their weights was highly essential. Our experience is too limited to give accurate opinion regarding the ideal disproportion in their weights. The greater the disparity in the weight (consequently blood volume) of the donor and recipient the lesser was the risk both to the donor and recipient. In one donor late death occurred on the third post-operative day, but no cause for death could be detected.

Temporary period of shock occurred in 5 donors in those experiments where high flow rates were used for prolonged period and was probably preventable if larger donor dogs were available. Majority of the donor dogs started breathing spontaneously within a very short time of the perfusion. They were quite fit on the following day of the perfusion. There was no post-perfusion bleeding tendency in any animal. The biochemical changes clearly show that the donor remains in an adequate physiological state throughout the perfusion. Accurate pre- and post-perfusion weighing did not reveal significant gain or loss of blood during perfusion except in one experiment.

In order to maintain the donor in an adequate circulatory state the donor should be hyperventilated prior to, during and after perfusion in order to prevent acidosis in both donor and recipients during the period of bypass. It is highly essential that 100% oxygen should be supplied to the donor during the period of bypass in order to assure a perfect oxygenation of both donor and recipient. A slow 5% glucose drip was found beneficial to maintain adequate blood pressure in the donor during bypass. Great care should be taken to return the same amount of blood to the donor as taken away from him by adjusting the pumps accurately.

The technique of controlled cross circulation provides a practicable method for establishing a total cardiopulmonary bypass and can be safely combined with chemical cardioplegia in the recipient. The physiological study during this procedure offers

sufficient testimony regarding soundness of the procedure particularly when used with higher flow rates than those suggested by previous workers.

Certain advantages of the procedure are quite obvious. The enormous volume of blood required for priming the heart lung machine is not necessary in this procedure. The extracorporeal contact is much less than in the mechanical oxygenators and therefore resulting hemolysis and bleeding tendency is markedly less. The natural lung of the donor is the most perfect oxygenator and thus can maintain a very high oxygen saturation of the arterial blood which is used for perfusing the recipient throughout the period of circulatory bypass. There is a great advantage of this method as the difficulties of maintenance of adequate oxygenation with mechanical oxygenation can be completely obviated. The method requires a very simple apparatus. The flow rates once adjusted rarely require any alteration throughout perfusion.

There are however certain disadvantages of this technique. One of the greatest drawbacks is that it exposes another healthy animal (donor) to at least minimal risk. In our work it has been demonstrated that this risk is minimal even with moderately high flow rates. This can be however further diminished if the rate of exchange of blood between the two animals can be further reduced. Another disadvantage of this method is that this method cannot be employed to support the circulation of adult animal as the flow rates available for maintaining its circulations are very high and

therefore not practicable. By reducing the quantity of flow rates of exchange this difficulty can be also further reduced.

method of controlled cross circulation in 35 animals.

(2) Chemical cardiac arrest varying from 10 to 30 minutes was brought about in the recipient dog in 10 experiments.

(3) Results of the experiments using different flow rates have been presented and discussed.

Summary

(1) Total cardiopulmonary bypass of 10 to 45 minutes was established by using the

REFERENCES

1. Andreason A. J. and Watson F.: Experimental cardiovascular surgery. Discussion of results so far obtained and report on experiments concerning a donor circulation. *British Journal of Surgery*, 41: 193-206, 1953.
2. Blum L. and Meigebow S. J.: Exclusion of the dog heart by parabiosis. *J. Mount Sinar Hosp., New York*, 17: 38-43, 1950.
3. Glenn W. L. W. and Sewell W. H. W.: Experimental cardiac Surgery IV. The prevention of air embolism in open heart surgery - Repair of interauricular septal defects. *Surgery*, 34: 195-206, 1953.
4. Lillehei C. W.: Controlled cross circulation for direct vision intracardiac surgical correction of interventricular, atrioventricular communis Tetralogy of Fallot defects. *Postgraduate Medicine*, 17: 388-396, 1955.
5. Southworth J. L. and Pierce E. G.: Cross circulation for intracardiac surgery. *Arch - Surgery*, 64: 58-63, 1952.
6. Warden H. E., Cohen M., Read R. C. and Lillehei C. W.: Controlled cross circulation for open intracardiac surgery. *J. Thoracic Surgery*, 28: 331-343, 1954.

—Received for publication on 10-4-1961.

INTERSEXUALITY

(with a case report)

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Advancement of the knowledge of sex chromatin has aroused an increasing interest in the subject of intersexuality. Sex diversities have been classified by Stewart⁸, under three major headings: (1) true hermaphrodite, (2) pseudohermaphrodite, and (3) chromosomal intersexes. In the recent years it has been established that each human cell contains 46 chromosomes^{8,9} and of these 23 pairs, 44 are autosomal and two are sex chromosomes. On the basis of anomalous chromosomal assemblage in the zygote, many types of intersexualities are explained. However, the primary defect in true hermaphroditism is still not clearly known. The number of cases of true hermaphroditism reported in the literature is small and it is felt that the report of this case with its interesting findings will be an useful addition to the existing literature.

Case Report

A boy of 15 years was admitted in the surgical wards of the S. N. Hospital on 8-5-1960 with the complaints of swelling and pain in the left testis for two months, and associated bilateral enlargement of the breasts. His parents stated that at birth this boy had a testis only in the right side of the scrotum, the left side being empty. The inferior aspect of the prepuce was attached to the scrotal skin and this was corrected by operation at the age of seven years. When he was 13 years old a tender swelling appeared in the left inguinal region near the external ring. Gradually the swelling increased in size and in about three months' time this mass finally occupied the left compartment of the scrotum.

Two months before his admission he sustained an injury to the left side of the scrotum which increased in size and became tender. The enlargement of the breasts started after this accident.

On general examination the boy was of normal height and weight according to his age. The penis was well developed. Distribution of pubic hair was of the male type. Axillary hair was present. Both the breasts were moderately enlarged. Apart from this no other female sexual character was noticed (Fig. 1, 2, 3).



Fig. 1

The general appearance is that of a boy. Penis is well developed and breasts are enlarged.



Fig. 2

Showing the external genitalia is well developed.

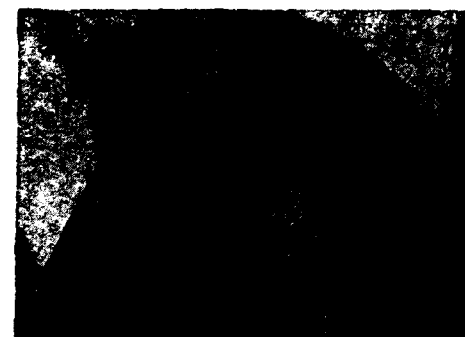


Fig. 3

Showing the enlarged breast as well as the well developed external genitalia.

Local examination of the scrotum showed a swelling on the left side, measuring $14 \times 7 \times 5$ cms., oval in shape with a smooth surface and firm in consistency.

Operation was done on 14-5-1960 under general anaesthesia. The mass from the left side of the scrotum was removed with the hernial sac. There was a cord like structure attached to the upper pole of the mass, which could be traced upto the base of the bladder.

On gross examination of the specimen the organs could not be made out. The irregular mass



Fig. 4

The irregular mass removed from the left side of the scrotum which was histologically proved to be different parts of the uterus and adenexae as labelled.

measured $13 \times 6.5 \times 3$ cms, pinkish white in colour and smooth externally. Cut surface showed one greyish-white structure at the central part measuring $4 \times 1.5 \times 1$ cm, with a cord like structure at the upper pole. At the lower portion of the mass there were a number of cysts, varying in diameter from 0.6 cm. to 1.2 cm., containing clear fluid or blood clot.

Microscopic examination of the sections from different parts of the mass showed that the greyish white structure was uterus. Section from this showed both myometrium and endometrium (Fig. 5).

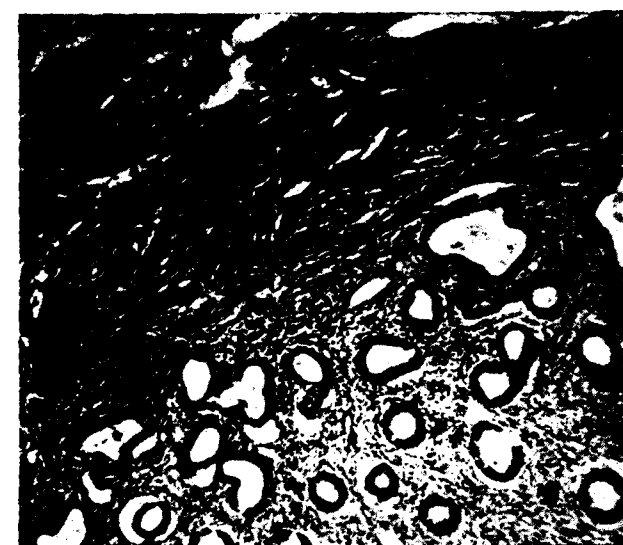


Fig. 5

Microsection from the greyish white structure, shows both myometrium and endometrium. H. & E. $\times 52$.

Microsection from the one end of this structure (Fig. 8). Section through the right testis showed revealed cervical histology (Fig. 6). Ovarian testicular structure (Fig. 9). Reconstruction of tissue was identified in the cystic area (Fig. 7), this mass after histological identification is shown in Fig. 4. and a fallopian tube was seen near the ovary



Fig. 6

Microsection from the one end of greyish white area - shows histology of uterine cervix.
H. & E. $\times 52$.



Fig. 7

Microsection from the cystic area. One graafian follicle and ovarian stroma are seen.
H. & E. $\times 150$.

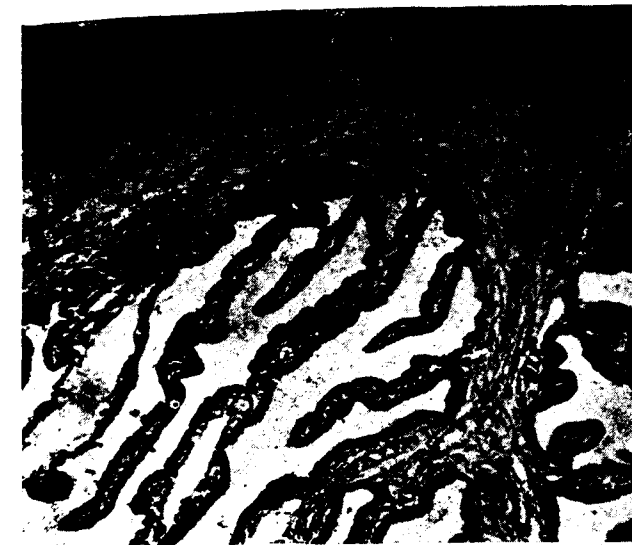


Fig. 8

Microsection from the area near the cystic mass - shows the histology of the fallopian tube.
H. & E. $\times 52$.



Fig. 9

Section from the right testis shows seminiferous tubules. Spermatogenesis is absent.
H. & E. $\times 52$.

Discussion

The present case can be placed among the rare cases of true hermaphroditism. Strictly speaking the diagnosis of true hermaphroditism should be based on histological evidences of the presence of both ovary and testis or ovotestis. In this patient biopsy from the right testis showed seminiferous tubules and the presence of Leydig cells but there was no evidences of spermatogenesis. The well developed penis, male type of pubic hair, general configuration and distribution of fat were further evidences of the presence of a functioning male gonad. In the mass in the left side of scrotum the presence of uterus, cervix, ovary and fallopian tube was established histologically. Recently Rath⁶ has reported the descent of a well developed uterus with its appendages into a hernial sac in an apparently male subject. In the present case the uterus and its appendages were only discovered on routine histological examination. Macroscopically the organs could not be identified probably due to their under developed and rudimentary state and the trauma with the resultant haemorrhage and adhesions had distorted the picture.

It is as yet difficult to explain the irregularity in the complex developmental process which leads to the formation of both types of gonad in the same individual. Various possibilities have been suggested. Greene³ advanced the hypothesis that genetic processes initiate the chain of

reactions which cause the difference between male and female structures. When the ovary or testis is determined it produces hormones which cause the other hitherto undifferentiated organ to develop towards masculinity or femininity as the case may be. He suggested that the fault in persons with separate ovary and testis is essentially genetic but with those possessing ovotestis the defect may be hormonal. It has been shown by certain workers^{5,7}, in experimental animals like rabbits or mice that if the undifferentiated gonads of embryos are removed they all develop along female line. This might be due either to an initially feminine bias or to the action of maternal oestrogen unopposed by embryonic androgens. Grumbach and Barr⁴ mentioned several examples of reversal of gonadal development in vertebrates induced by hormonal treatment. However these experiments have not been able to throw light on the etiology of human hermaphroditism.

In the true sense, hermaphrodites should have active fecundity both as male and as female which is not possible in *homo sapiens*. Hence it is thought as Crew¹ has suggested that these conditions should better be designated as cases of high grade of intersexuality.

Summary

A case of hermaphroditism which showed the presence of both male and female reproductive organs in the scrotum is reported. Views about the cause of hermaphroditism have been discussed.

REFERENCES

1. Crew, F. A. F.: J. Post. Grad. Med., 6/3: 101, 1960.
2. Ford, C. E. and Hammerton, J. L.: Nature, 178: 1020, 1956.
3. Greene, R. R.: J. Clin. Endocrin, 4: 335, 1944.
4. Grumbach, M. M. and Barr, M. L.: Recent progress in hormone research, 14: 303, 1958.
5. Jost, A.: Arch. Anat. Micr. Morph. Exp., 36: 271, 1947.
6. Rath, S. B.: J. I. M. A., 35/2: 70, 1960.
7. Raynaud, A. and Frilley, M.: Ann. Endocr., Paris, 8: 400, 1947.
8. Stewart John, S. S.: Proc. Royal Soc. Med., 52/10: 817, 1959.
9. Tijjo, J. H. and Levan, A.: Hereditas, 42: 1, 1956.

—Received for publication on 25-1-1961.

ORTHOPAEDIC SECTION

CLINICAL AND EXPERIMENTAL OBSERVATIONS ON THE PRODUCTION OF "MYOSITIS OSSIFICANS TRAUMATICA" FOLLOWING ELBOW INJURIES*

BY

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The incidence of Myositis Ossificans as a complication of injuries of the elbow following treatment by local bone-setters in India is fairly high, it is by far the commonest late complication met with in fractures and dislocations around the elbow, in cases treated outside an organised fracture unit. The bone setters generally treat these cases of fresh elbow injuries by single or repeated manipulations and massage. However, it has been observed that history of repeated passive manipulations is not forthcoming in all the cases which go on to myositis ossificans and the converse is also sometimes true. It is one of the most serious lesions since it brings about limitation of elbow movements and even complete fixation of the elbow by causing extra-articular ankylosis which is a very difficult problem to treat. Stiff elbow on account of myositis ossification is difficult to salvage by any operation (Figs. 1 & 2).

Myositis ossificans or periarticular ossification also occurs in injuries of the hip, thigh and other joints but the incidence is very much less common as compared to that of the elbow. Why it peculiarly happens in cases of injuries around the elbow and what factors contribute to the precipitation of this new bone, remains a problem.

Experimental production of Heterotropic Ossification

By experimental work some light seems to have been thrown on the causation of



Fig. 1

Extensive Myositis Ossificans around the elbow.

heterotropic ossification. Bone has been produced experimentally by ligation of the vessels of the kidney and wrapping the omentum about it (Sacerdotti and Frattin, 1902) and by transplantation of the mucous membrane of the urinary bladder in the anterior rectus sheath (Huggins, 1931). Extra skeletal osteogenesis and chondrogenesis has also been obtained into the muscles of rabbits by injecting alcoholic extract of normal bone or of the callus from a fracture in an animal of the same species (Lavender, 1938).

*Paper read at the Summer Meeting of the Orthopaedic Section of the Association of Surgeons of India in August 1961 at Ahmedabad.



Fig. 2

Extra-articular (humero-ulnar) ankylosis elbow due to bridge of myositis ossificans in the triceps.

Theories of Genesis of Myositis Ossificans

Myositis ossificans after elbow injuries, has been known for 200 years or more and much has been written about its origin and pathology. Since it is a benign lesion, and because any attempt at its removal in its early formative stages is followed by extension of the process, practically all the descriptions about its pathology have been on the basis of radiographic findings or after operations on the cases with consolidated bone masses needing removal for their mechanical effects. Hence, the exact detailed description of the pathology and histology of the early and successive stages in the genesis of myositis ossificans is not available. Varying and patchy accounts have been given, and depending on this, different theories about the origin of osteogenesis and mechanism of precipitation have been put forward. However, in essence, all these theories fall in the following groups:

(1) One of the theories of the formation of myositis ossificans is that the osteoblasts

escaped from the adjacent bone and proliferated into the muscles and laid down bone in the muscle belly itself. In extreme cases whole of the muscle may be replaced by bone. Occasional x-rays are available where the new mass of bone takes up the shape of the lower part of biceps and its tendon of insertion and is lying separately from the main bone. (Fig. 3). These would be the cases of true "Myositis Ossificans", that is, ossification in the muscle itself.

(2) According to another theory the new bone formation is supposed to be nothing more than the ossification of a subperiosteal haematoma (Greig, 1931). This theory has been very strongly advocated by Watson Jones (1934) and it has been mentioned that this complication is most often seen in children. However, from the study of our cases we find that this complication was more frequent in elbow injuries of adults, i.e., 72%. In some cases, particularly



Fig. 3

Myositis Ossificans in the lower part of the biceps and its tendon.

following supra-condylar fractures in children where some degree of displacement persists, subperiosteal bone formation is seen in radiographs which is very much orderly, forming in the confines of the periosteal tube adjacent to the bone and finally consolidates to remodel the bone (Fig. 4). This type of bone formation is not to be confused with myositis ossificans.

(3) Yet another hypothesis is that the new bone arises by metaplasia of the local fibrous tissue. Normally in all the processes like embryonic development of bone and repair of fractures etc. bone has been formed from connective tissue. The fibrocyte, chondrocyte and osteocyte are probably derived from the parent connective tissue cell called mesenchymal cell. Under the influence of little understood factors, different or at least allied type of cells can be produced especially in the case of connective tissue cells.



Fig. 4

Subperiosteal extra bone formed in a case of supra condylar fracture to remodel the fracture site.

(4) Virchow in 1894 postulated, and others still believe, that there is a constitutional or inherent tendency—a "Diathesis Ossificans"—for the fibrous tissue to react to injury by metaplasia in bone. This may be more true in cases of Myositis Ossificans Progressive which is not an allied entity aetiologically, pathologically or clinically to the traumatic form.

(5) Still other factors like metabolic imbalance (especially local calcium hyper concentration in the traumatised muscular tissue) glandular disorders, changes in the acid-base balance of blood (Sanders, 1955) or local chemical factors acting as a stimulus for the ossification in the Haematoma, have also been thought important. However, most of these theories have been already discarded.

Material and Methods

The main aim of this experimental work was to be able to produce new bone corresponding to the clinical "Myositis Ossificans Traumatica" so as to study the exact pathology of this condition at the various stages of its genesis. Also, if possible, to have some idea about the different factors and the mechanism of precipitation and origin of this ectopic bone in the traumatised tissues, thereby hoping to formulate the ways and means to prevent the formation of this bizarre bone. In the preliminary experiments done at the Orthopaedic Department, All India Institute of Medical Sciences, New Delhi, the author had succeeded in the production of some bone deposits in the elbow regions of the dogs. Since coming to this Institution in Pondicherry, the whole problem has been studied in the guinea pigs and a total of 60 animals have been experimented upon.

Mature guinea pigs with an average weight of about 500 gms. (varying from

400 to 600 gms.) were used. Under open ether anaesthesia, postero-lateral dislocation of one of the elbow regions of the fore-limbs was done without open operation. With the fore-limb short of full extension, by carefully abducting and adducting the elbow the collateral ligaments were broken and then dislocation could be easily created. If due care is not taken, fracture of the bony members, occurs and such cases were excluded from further study. Dislocation was selected as a method of choice, because it is said to be more commonly associated with myositis ossificans clinically and also, it does not bring in the additional factor of fracture haematoma and the associated repair process in the picture to complicate the interpretations. However, occasionally bone-chips were seen to get pulled off and their role in the formation of this ectopic bone

would be discussed later. After the dislocation, passive manipulations were carried out daily. These repeated manipulations were done manually and without anaesthesia and not very violently as in some of the cases of the experimental group A. It was made sure that the dislocation was maintained and the false joint moved through the possible normal and abnormal range 4-5 times.

Serial x-rays were taken usually at weekly intervals for 4 to 6 weeks, and later at six to eight weeks intervals. The duration of manipulations and the time after which the animals were sacrificed, varied and the experimental observations were collected in groups as shown in the (Tables No. 1 & 2). The tissues so collected were submitted to Histopathology after decalcification. Routinely H. & E. staining was done, but in some cases

TABLE No. 1
Experimental Procedure done on Elbow—To Study Production of ‘Myositis Ossificans’
Total No. of Animals 60

Group	Experimental Procedure Done	No. of Animals
A	Joint Dislocated—No manipulation	5
	Do —Manipulation daily till animal killed	34
	Do —Manipulation daily with Violent manipulation under G. A. after 1 week	5
	Do —Haematoma aspirated after 24 Hours	2
B*	Joint Dislocated—Manipulation stopped after 1 day	3
	Do — do do 2 days	3
	Do — do do 4 days	2
	Do — do do 8 days	2
C*	Joint Dislocated—Reduced at once—No Manipulation	1
	Do — do —Manipulation Daily	1
	Do —Reduced after 24 hours No Manipulation	1
	Do — do 24 hours Daily Manipulation	1

*Further experiments under study.

TABLE No. 2
Period after which the Tissues collected for Histopathology
Total No. of Guinea Pigs-60
Total No. of Guinea Pigs alive deducting number from which Tissue could not be Collected-13

Serial No.	Time after Experimentation	No. of animals
1	Just after dislocation	1
2	One week or less	5
3	1 to 2 weeks	5
4	3 to 4 weeks	5
5	4 to 5 weeks	5
6	5 to 6 weeks	6
7	6 to 8 weeks	6
8	10 to 14 weeks	6
9	24 to 32 weeks	4
10	One Year or over	4
Total		47

special staining like Gomori's was done to know the distribution of alkaline phosphatase in the newly forming bone. As a routine more than one section were studied which were taken at varying depth. In some of the tissues serial sections of quite a big block were studied in order to get a proper and a three dimensional idea of the newly formed bony mass.

Histological Observations

Normal.—The anatomy of elbow region of the fore-limb in the guinea pig resembles the human one very closely except that the head of radius seems to be placed on a more anterior plane rather than fully laterally.

Pathological.—In the cases of experimental posterior dislocation, the anterior joint capsule was seen to get ruptured with the attached anterior muscle mass (brachialis and biceps) which showed laceration and

breaking up of the muscle bundles since this was closely applied to the capsule. Similarly the muscle fibres of the posterior muscle mass (triceps) got lacerated for a varying distance depending upon the violence of the trauma and the amount of dislocation obtained. The posterior haematoma was almost always bigger than the anterior one and extended for a greater distance up the shaft.

Following the muscle tear, the haemorrhage was organised by the characteristic formation of granulation tissue and progressive fibrous tissue replacement. This organised traumatic haematoma also extended to some extent along the inter-fibrillary connective tissue in the deepest part of the muscle mass which had survived the laceration. The lacerated and fragmented muscle bundles, however, exhibited signs of muscle fibre degeneration in the form of swelling and intense acidophilic staining with loss of nuclei and striations and got replaced by fibrous tissue.

About the centre of the organised granulation tissue, the fibrous tissue cells presented a more primitive appearance and formed as a mass of proliferated mesenchymal cells which were small with scanty cytoplasm and dark staining nuclei. In some of these areas of young proliferated mesenchymal cells, we got multiple areas of endochondral ossification which went on progressively adding bone trabeculae as the cartilage cells matured. Rarely, there was direct bone metaplasia without going through the stage of cartilage (Fig. 5 and 6). There was a tendency for these newly formed cancellous bony masses to coalesce and also get attached to the adjoining bone—mainly the lower part of the humerus and sometimes the olecranon process of ulna. These bony masses may, however, remain separate and mature into coarse fibred cancellous bone

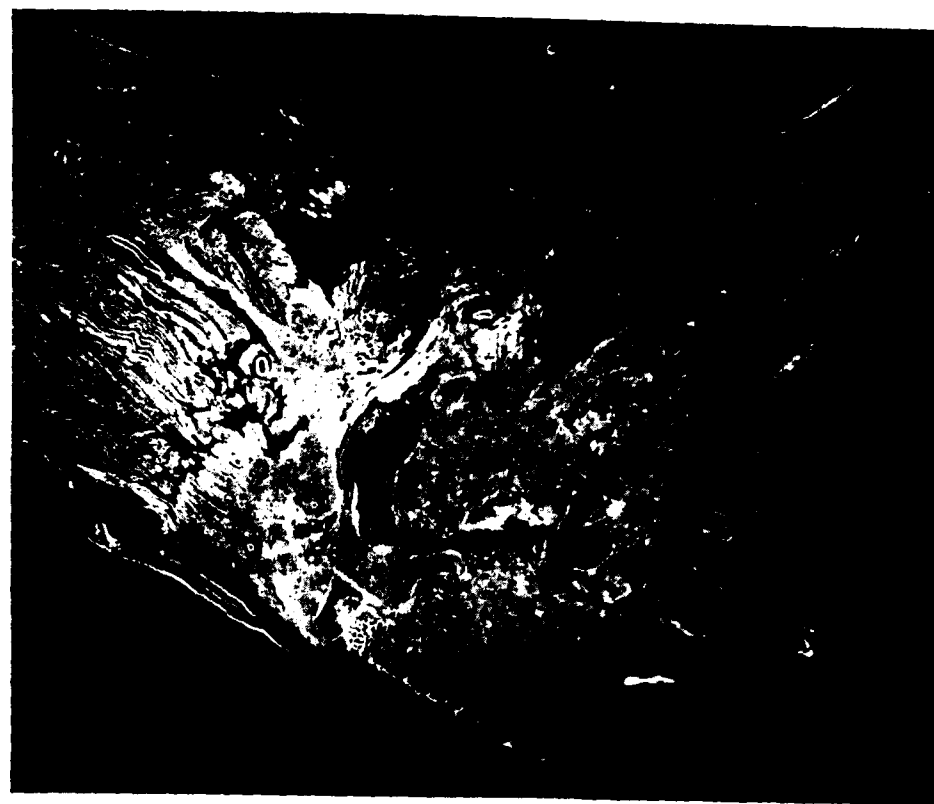


Fig. 5

Enlarged photograph of the histological section showing multiple areas of new bone in the posterior haematoma.



Fig. 6

Low power microphotograph (staining with Gomori's technique) showing the progressive changes of endochondral ossification from fibrous tissue into cartilage, immature and mature bone.



Fig. 7

Microphotograph showing multiple areas of direct metaplasia of fibrous tissue into bone.



Fig. 8

Enlarged photograph of histological section showing two areas of endochondral ectopic bone, one of which has a well marked area of cancellous tissue in the centre. These bony masses had a tendency to get attached to the subperiosteal bone formed along the posterior cortex of the humerus.

surrounded by the fibro-fatty tissue (Figs. 8, 9 and 10).

The bony tissue is formed more constantly and as bigger masses in the posterior organised haematoma and less often in the anterior. Sometimes there are two bone masses opposite each other attached to the lower posterior aspect of the dislocated humerus and the olecranon region with formation of a pseudo-joint in between covered over by a modified fibro-cartilage and joint space. In none of the specimens studied did we get the

condition akin to extra articular ankylosis as seen clinically. Also, no specimen showed complete disappearance of the bone once it was seen on radiography. The bone, however, became smaller, more mature and dense on x-rays, with the clear outline and most often attached to the shaft.

Besides this irregular bone metaplasia in separate centres in the proliferated mesenchyma, there was also observed the orderly subperiosteal bone formation which was sometimes quite marked. This was almost always



Fig. 9

Microphotograph of one of the areas in Fig. 8 showing subperiosteal bone to the right and the newly formed cartilage and bone areas on the left separated by a little fibrous tissue.

ossification in membrane and was in the form of trabeculated bone of practically uniform width tapering into a triangular area as the layer was traced upwards and extended usually beyond the limit of the organized haematoma under the muscle fibres. As mentioned before, the new endochondral bone gets connected on the surface of this subperiosteal bone separated by little fibrous tissue (Fig. 9) or the trabeculae become continuous with this and form one or two big lumps on the surface.

Third type of bone which has been rarely observed was at the bony attachment of the ligaments especially at the posterior lip of olecranon fossa. This also, was usually formed in cartilage (Hyaline or fibro-cartilage) and was very much limited in extent and corresponded to the ligamentous "calcification"—observed clinically in some of these cases. It was observed only in three specimens out of a total of 47 studied histopathologically.

The new bone differed in form and size and was ill defined to begin with and there

were large irregular masses of it occupying the whole of the traumatic haematoma. In no case was the new bone found invading the muscles or the interfibrillary connective tissue. However, in some of the cases, the fragmented muscle fibres which did not degenerate and get replaced by the fibrous tissue, were seen separating the bone foci and gave the erroneous impression that there was an invasion of the muscles and that it was a "Myositis ossificans". It would be better to term the condition as "Fibrositis ossificans", or simply "Periarticular Ossification."

Histological and Radiological Findings at Various Stages

No. (1) Tissues Collected after one week.—

It was found that within one week there was evidence of subperiosteal ossification which was young and immature as yet. The haematoma showed organisation and the small multiple areas of cartilage and endochondral ossification appeared and even started forming some bone trabeculae. In spite of



Fig. 10

Areas of mature, coarse fibred cancellous bone lying deep to muscle bundles surrounded by fibrofatty tissue. The dislocated lower end of humerus is seen to the right.

the fact that some areas of new bone formation could be seen on histology, the x-rays were uniformly negative, perhaps, because there was not enough calcium to give a shadow.

No. (2) Two to Three weeks.—The main findings remained the same except that the subperiosteal bone got more organised and practically stationary. The areas of metaplastic bone became bigger but still showed continued activity of the ossification centres and coalescing of some of the contiguous areas. At this stage some fluffy shadows of new bone were seen, mainly posteriorly and sometimes occupying the olecranon fossa. (Fig. 11).

No. (3) Four to Eight weeks.—The newly formed ectopic areas showed maturity of the bone foci, which tended to become stationary and the fibrous tissue surrounding it became further organised into bundles with decrease in the total area. The x-rays



Fig. 11

X-ray print showing fluffy areas of new bone formation 3 weeks after experimental dislocation and passive manipulations in a guinea pig.

showed well formed masses of bone (Fig. 12 and 13).

No. (4) Over Eight weeks to One year.—In the tissues studied after eight weeks of experimentation, the new bone was seen to get



Fig. 12 & 13

Lateral and A. P. x-rays 8 weeks after dislocation. Two well formed masses of bone are visualised in para-articular tissues.

fully matured with concentric lamelle and the spaces filled with bone marrow. Usually the bony lumps, which may be lying adjacent to each other, got a covering of fibro-cartilage and formed a sort of pseudo-joint. This specially happened in the bony masses where one was filling the olecranon fossa and the other was attached to the shaft of the humerus.

Discussion

Now the question arises what factor or factors are there which start off or trigger this bone induction or metaplasia of the fibrous tissue which is formed as a part of the granulation tissue to replace the traumatic haematoma. What is the exact stimulus for ossification? Is it the periosteum or the small broken bone fragments which act as grafts and proliferate to give rise to ectopic bone or is there some change in the local or blood chemistry of calcium, phosphorus and alkaline phosphatase or some other change in the environment of the proliferating fibroblasts which brings on this metaplasia? Some of these factors were studied and the following observations made.

(A) *Role of Periosteum and Detached Ligaments.*—There is no doubt about stripping of the periosteum but the subperiosteal bone formation is distinct and more orderly and can be seen to have the limiting membrane under which the new bone trabeculae form by intramembraneous ossification. The other bone foci are usually seen in the rest of the fibro-fatty tissue outside this area and also, these areas are most often formed in endochondral ossification in the centre of fibrous tissue and occasionally cartilage. Though, proliferation of this fibro-cartilage was seen near the end of ligaments but was not found to be the one starting the foci of bone in the tissue in any of the sections examined.

(B) *Role of Broken Pieces of Bone and Articular Cartilage.*—It has been surmised that the myositis ossificans is more common in cases where there are small chipped off fragments of the condyles etc., which act as cancellous bone transplant. A study of the histopathological sections was undertaken with a view to assess the possible role of the broken off pieces of bone and articular cartilage. These were seen in 4 of the specimens. No osteogenic or proliferative reaction was seen around these fragments. In two of these cases broken pieces of cartilage were seen to be similarly lying inert.

(C) *Tissue and Blood Chemistry Studies.*—Since the description of important function of alkaline phosphatase in new bone formation by Robinson and Soames (1924), the role of this in the metaplastic bone formation has been extensively discussed. In some of the tissues staining with Gomori's technique was done to see the distribution of alkaline phosphatase in the newly developing bone. It was observed that alkaline phosphatase was present only during the active phase of ossification and only in those areas of the fibrous tissue where the metaplastic or subperiosteal bone formation was in progress (Fig. 6). In fact this staining seems to be a convenient method of finding out the new bone foci.

Some authors have reported an increase in the amount of calcium salts in the blood serum during the occurrence of metaplasia of fibrous tissue into bone. Serum calcium, inorganic phosphorus and alkaline phosphatase studies were carried out in some of the experimental animals. A total of 20 observations were made in animals sacrificed from one week to fourteen weeks after experimentation. The findings are as in Table No. 3.

It shows that during the process of this metaplastic ossification, serum calcium and

TABLE No. 3

Estimation of Blood Chemistry in Guinea Pigs showing Metaplastic Ossification

Time after Experiment	No. of G. P.	Serum Calcium	Serum Inorg. Phos.	Serum Alkaline Phosphatase
Normal ...	5	From 14.0-14.9 Average 14.5 mg. %	From 1.8-4.0 mg. % Average 2.8 mg. %	From 1.3-2.7 A. U. Average 1.8 A. U.
1-2 Weeks ...	5	Average 12.2 mg. %	Average 6.9 mg. %	Average 5.2 A. U.
2-4 Weeks ..	5	Average 12.6 mg. %	Average 6.8 mg. %	Average 7.2 A. U.
4-8 Weeks ...	5	Average 12.1 mg. %	Average 6.3 mg. %	Average 4.3 A. U.
8-14 Weeks ...	5	Average 11.3 mg. %	Average 4.5 mg. %	Average 4.1 A. U.

phosphate ratio changes and inorganic phosphates show a marked increase with the increase in the alkaline phosphatase, which to some extent comes down in the animals killed after eight weeks. However, the observations are too few to draw any definite conclusions.

(D) *Role of Reduction of Dislocation.*—There was a definite difference in the cellular reaction of the haematoma in the animals where immediate reduction had been done (Figs. 14 & 15). There were seen no foci of new bone and cartilage, and the fibrous tissue showed more areas of fatty tissue intermixed with endothelium lined spaces. The subperiosteal bone was formed minimally or none at all. This was in contrast to the cases where the dislocation was left unreduced where even in the first one week, we found evidence of the new endochondral bone foci appearing in the midst of young mesenchymal cells.

(E) *Aspiration of the Traumatic Haematoma.*—In some of the animals of group 'A', the haematoma was tried to be aspirated after 24 hours of dislocation. Only about 1 to 1.2 cc. of blood stained fluid could be aspirated. Even though no manipulations were done, multiple areas of new bone formation and subperiosteal bone were seen.

Since aspiration was done after 24 hours and only some oedema fluid with blood staining could be taken out, it seems the blood had coagulated and infiltrated the surrounding muscles in the meantime. Also, the joint had remained dislocated. Due to all these factors it looks, aspiration could not decrease the incidence of the new bone formation.

Conclusions

From the overall study of this experimental data, the main factor seems to be the presence of an extensive haematoma with tearing of the ligaments and muscle fibres and the separation of the periosteum due to wide dislocation of the fragments. If this haematoma is allowed to get organised, new fibrous tissue develops, the cells of which quickly proliferate and form certain areas of probably pluripotent primitive mesenchymal cells which give rise to multiple areas of endochondral ossification that later coalesce. Some of these areas get continuous with the subperiosteal bone and form into bone masses which vary in size and shape. It is no doubt an ossification in the traumatic haematoma but it is not wholly subperiosteal as stressed by Watson Jones and others. To start with, both types of bone (subperiosteal and metaplastic) form though later on one may become attached to the other. Of

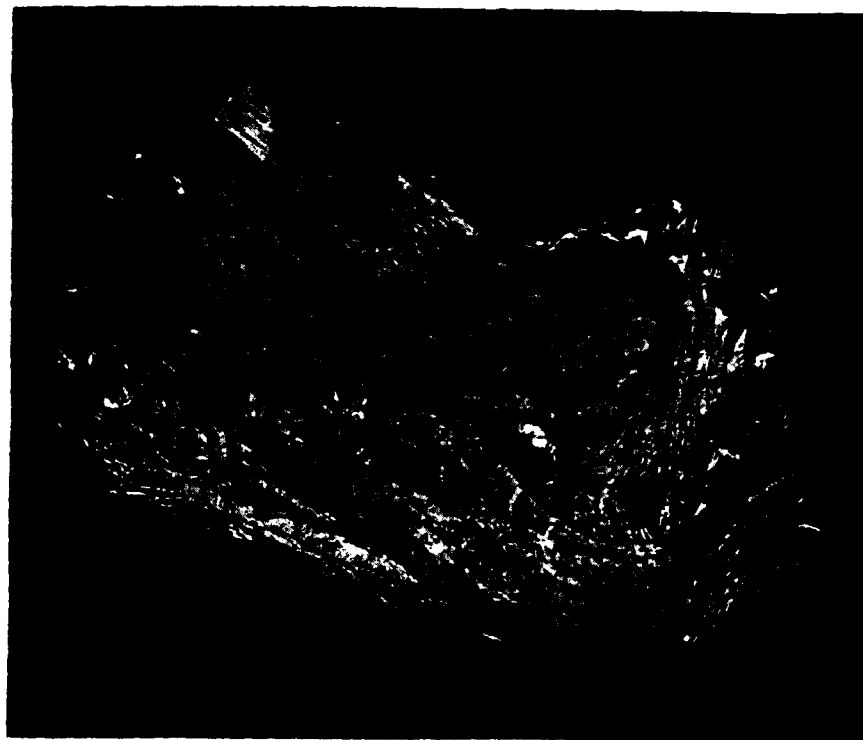


Fig. 14

Enlarged photograph of the histological section showing reduction of the dislocation. No areas of new bone were seen.

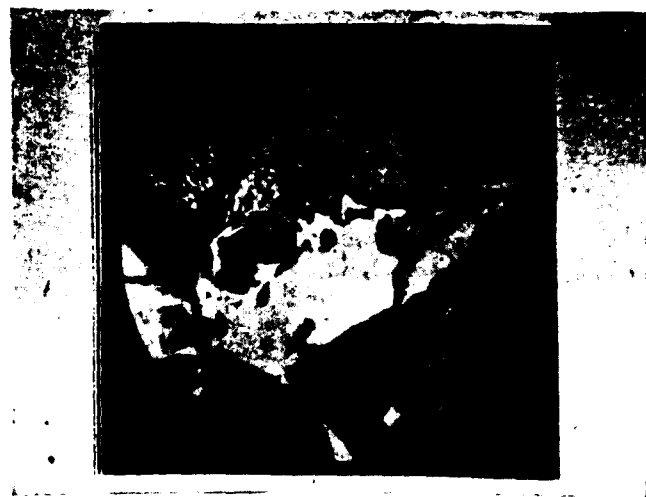


Fig. 15

Microphotograph of an area as seen in Figure 14 in the posterior part of the haematoma. Fibrofatty tissue with a big space lined by endothelium is seen.

course it is not a true ossification of the muscles but only ossification in the newly formed fibrous tissue which replaces the haematoma and the degenerated muscle fibres. The occasional fractured pieces of bone and cartilage do not serve as the starting point of this new bone. Major precipitating factor seems to be that, if a big haematoma is allowed to persist by delaying reduction or is increased by passive manipulations, the process is put in motion. It is interesting to note that within the first week the whole stage gets set for the formation of this ectopic bone, and later it is only the maturation and consolidation of this process. First few days after injury seem to be most crucial and any delay in the reduction of the dislocation or temperance with the repair process, as is perhaps done by the local bone-setters by passive manipulations and massage, we get a stiff elbow with new bone masses around. Controlled experiments to study the relative role of these factors are under way as an extension of this problem and would be presented sometime again.

In the end, I would like to emphasize that, although much has been learnt about the genesis and development of bone in normal and ectopic situations from clinical and experimental observations (including tissue culture and tissue transplantations), still many fundamental questions remain unanswered. In clinical practice the significance of some of the experimental observations is still unknown, but, once we get results whose constancy contrasts with the diversity of previous observations, the significance should be great. This problem of metaplastic new bone formation is an interesting one and is of wider clinical interest. Its solution, if it could be obtained or even glimpsed, would be useful. If we could fully understand the various local cellular and biochemical changes which

bring about the production of this bizarre bone and are able to produce or interrupt these at will, we would have reached another milestone in Orthopaedics.

Summary

(i) Stiff elbow with myositis ossificans is found to be the commonest late complication following elbow injuries treated by "local bone setters" in India.

(ii) New bone deposits corresponding to the clinical "Myositis ossificans traumatica" were produced in guinea pigs by creating closed dislocation of the elbow region and doing passive manipulations daily.

(iii) Under varying experimental conditions, a total of 60 guinea pigs were studied so as to know the exact pathology of this condition at the different stage of its genesis by means of serial X-rays and histopathology in tissues collected from one week to one year after experimentation.

(iv) The bone was found to start as multiple endochondral bone foci in the newly formed fibrous tissue which replaced the traumatic haematoma, and was distinct from the subperiosteal bone which also was seen to form. However, later in some of these areas, the two types of bones coalesced with each other.

(v) Role of the various factors like detached periosteum and the ligaments, chipped off bone pieces and articular cartilage etc., in the formation of ectopic bone foci was found to be negative; while there was a minimal subperiosteal bone formation and none of the ectopic type in elbows where the dislocation was reduced immediately.

(vi) The main precipitating factor seems to be the presence of a big haematoma if that is allowed to persist by delaying the

reduction or the repair process is tampered with during the first one week after injury when the process is already seen to get set in motion for both types of bone formation.

Acknowledgements

My grateful thanks are due to my wife Dr. (Mrs.) M. Gupta who was a constant help during the collection of this experimental data, especially in doing daily manipulation of the joints as well as getting the serial

radiographs taken. I am indebted to Dr. S. K. Lal, M.D., Professor of Physiology and Dr. V. M. Charnalia, M.S., Professor of Anatomy for getting me all the technical help. To the staff of Biochemistry Department, I owe my thanks for doing the biochemical investigations and to Mr. Safiullah for the preparation of the sections for histopathological study.

REFERENCES

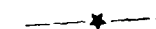
1. Asami, Gand Dock, W.: Experimental studies on heteroplastic Bone formation. *J. Exper. Med.* 32: 745, 1920.
2. Bridges, J. B. and Prichard, J. J.: Bone and cartilage induction in Rabbit, Rat and Guinea Pig. In proceedings of the Bone and Tooth Society. *J. Bone and Joint Surg.* 39-B: 591, 1957.
3. Bowers, R. F.: "Myositis Ossificans Traumatica". *J. Bone and Joint Surg.* 19: 215, 1937.
4. Bristow, R.: "Myositis Ossificans", *Brit. J. Surg.* 11: 475, 1923.
5. Bristow, W. R.: Myositis Ossificans and Volkmann's Paralysis. *Brit. J. Surg.* 10: 475, 1923.
6. Binnie, J. F.: On myositis ossificans traumatica. *Ann. Surg.* 38: 423-440, 1903.
7. Costello, F. V. and Brown, Austin: Myositis ossificans complicating Anterior Poliomyelitis. *J. Bone and Joint Surg.* 33-B: 594-597, Nov. 1951.
8. Freiberg, J. A.: Para-Articular calcification and Ossification Following Acute Anterior Poliomyelitis in an Adult. *J. Bone and Joint Surg.* 34-A: 339-348, April 1952.
9. Geschickter, C. F. and Maseritz, I. H.: "Myositis Ossificans", *J. Bone and Joint Surg.* 20: 661, 1938.
10. Gordon, S. and Ham, A. W.: The fate of Transplanted cancellous bone - In the Gallie Addresses, p. 296, Toronto, Univ. Toronto Press, 1950.
11. Greig, D. M.: "Traumatic Osteoma of Long Bones". *Surg. Path. Bone*, 170, Edinburgh, Oliver and Boyd Ltd., 1931.
12. Gruca, A.: Myositis ossificans circumscripta, *Ann. Surg.* 82: 883-919, 1925.
13. Ham, A. W. and Harris, W. R.: Repair and transplantation of bone - In the Biochemistry and Physiology of Bone, New York, Acad. Press, 1956.
14. Ham, A. W. and Gordon, S. D.: The origin of bone that forms in association with cancellous chips transplanted into muscle. *Brit. J. Plast. Surg.* 5: 154, 1952.
15. Heinen, J. H. Jr., Dabbs, G. H. and Mason, H. A.: The experimental Production of Ectopic cartilage and Bone in muscles of Rabbits. *J. Bone and Joint Surg.* 31-A: 765-775, Oct. 1949.
16. Hess, W. E.: Myositis Ossificans occurring in Poliomyelitis. *Arch. Neurol. and Psychiat.* 66: 606-609, 1951.
17. Huggins, C. B.: The formation of bone under the influence of epithelium of the urinary tract. *Arch. Surg.* 22: 377, 1931.
18. Johnson, J. T. H.: Atypical Myositis Ossificans. *Journal Bone and Joint Surg.* 39-A: 1139, 1957.
19. Huggins, C. B.: Phosphatase activity of transplants of epithelium of the urinary bladder to abdominal wall producing heterotopic ossification. *Biochem. J.* 15: 729-732, 1951.

20. Katz, I. and Levine, M.: Bone formation in Laparotomy Scars., *Amer. J. Roentg.* 84: 248, 1960.
21. Leriche, R. and Policard, A.: Les problèmes de la physiologie normale et pathologique de l'os. Masson & Co, Paris, 1926.
22. Leriche, R. and Policard, A.: Some fundamental principles in Pathology of bone, *Surg., Gynec. & Obst.* 43, 308-309, 1926.
23. Lindahl, O. and Orell, S.: Experiments with bone extracts, *Acta. Chir. Scandinav.* 101-136, 1951.
24. Mosiman, R. S.: Discussion on the paper by Urist, M. R. and McLean F. C., *Journ. Bone and Joint Surg.* 34-A, 470-476, 1952.
25. Robison, R.: The possible significance of hexosephosphoric esters in ossification, *Biochem. J.* 17, 286, 1923.
26. Robison, R. and Soames, K. M.: The possible significance of Hexose-Phosphoric esters in Ossification, Part II. The Phosphoric esterase of ossifying Cartilage. *Biochemical Journal*, 18, 740, 1924.
27. Rosenstirn, J.: Contribution to study of Myositis ossificans, *Ann. J. Surg.* 68: 485, 1918.
28. Sacerdote, C. and Frattin, G.: Veber die heteroplastische knochenbildung. *Arch. F. Path. Anat. U. Physiol.* 168, 431, 1902.
29. Sanders, R. L.: Bone formation in upper abdominal scars, *Ann. Surg.* 141, 621-626, 1955.
30. Shipley, A. M.: Ossifying Hematoma and Allied Conditions, *Arch. Surg.* 41: 516-524, 1940.
31. Thorndyke, A.: "Myositis ossificans traumatica", *J. Bone and Joint Surg.* 22: 315, 1940.
32. Urist, M. R. and McLean, F. C.: Osteogenic potency and new bone formation by induction in transplants to the anterior chamber of the eye. *J. Bone and Joint Surg.* 34-A: 443, 1952.
33. Virchow, R.: Report on the Pathology of Myositis Ossificans progressive (Quoted by Bick in source Book of Orthopaedics 2nd Ed.) 1894.
34. Watson-Jones, R. and Roberts, R. E.: "Calcification, Decalcification and Ossification", *Brit. J. Surg.* 21, 461, 1934.

BOOKS REFERRED

1. Bourne, G. H.: The Biochemistry and Physiology Bone, New York, Acad. Press, 1956.
2. Lacroix, P.: The organization of Bones, translated from the amended French edition by Stewart Gilder, New York, Blakiston Division of McGraw-Hill, 1951.
3. Maximow and Bloom: Text Book of Histology. 5th Edition, Philadelphia and London, W. B. Saunders Company, p. 147.
4. McLean, F. C. and Urist, M. R.: Bone, an introduction to the Physiology of Skeletal Tissue, Chicago, Univ. Chicago Press, 1956.
5. Stein, Irvin, Stein, Raymond O. and Beller, Martin: Living Bone in Health and Diseases, Philadelphia, Lippincott, 1955.
6. Weinmann, J. P. and Sicher, H.: Bone and Bones. Fundamentals of Bone Biology. Second edition. C. V. Mosby Company, St. Louis, pp. 309-314, 1955.
7. Wolstenholme, G. E. W. and O'Connor, C. M.: Ciba Foundation Symposium on Bone Structure and Metabolism, London, Churchill, 1956.

—Received for publication on 30-10-1961.



PLASTIC SURGERY SECTION

RECONSTRUCTIVE SURGERY OF THE NOSE

BY

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The art of Rhinoplasty is not new to the Indian Surgeons as it was being practised with success in the days of Shushruta. It seems feasible that the first Rhinoplasty was done in our country if one believes in the age old saying that necessity is the mother of invention; because according to our Indian tradition depriving some one of his or her was supposed to be the best way of punishment. The cut nose, therefore, in our country signifies a heinous crime committed by the individual for which he or she has been awarded this punishment in revenge. The midline forehead Rhinoplasty that was first being practised is still perhaps, by far, the best method of nose reconstruction. Whenever feasible this flap can be utilized for all the varieties of nose defects.

Author's experience is based on a study of 67 nose reconstructions that he has done himself, from the year January 1953 to December 1960. Eighty-nine cases in all were admitted to the Gandhi Memorial & Associated Hospitals, Lucknow, of which 77 only underwent reconstruction. In 75 patients the reconstruction has been completed, while two are still awaiting the final stages of repair. During this study the sex incidence has been worked out along with the aetiology. However, this work will mainly review the techniques employed and their results in various types of defects. Lastly, an attempt has been made to evaluate the advantages, disadvantages, causes of

failures as experienced by the author and their remedy.

Sex Incidence

Out of the total cases of 89, 38 were females while 51 were males. This surprisingly shows that it is more common amongst males in this part of the country rather than the fairer sex, although it is a prevailing belief that the incidence of cut nose is more common amongst females. It was observed that amongst females it is more common in the younger age groups i.e. between 18 to 31 years, while no age is exempt in the cases of males.

Aetiological Factors

In 89 patients, 74 noses were lost due to criminal assaults of which 4 were mauled by dacoits, while in the rest it was a revenge due to personal animosities and jealousies. Out of these 74 cases, 42 were males and 32 females. Two were due to human bites (both females) while sharp instruments were used for the rest. In 11 cases it was accidental out of which 2 were as a result of attack by bear. Two were post inflammatory the nature of which could not be definitely ascertained due to poor information provided by the patients. One was leutic and in another it was due to Lupus.

Varieties and Classification

Loss of nose has been divided into following categories Figure 1-A.

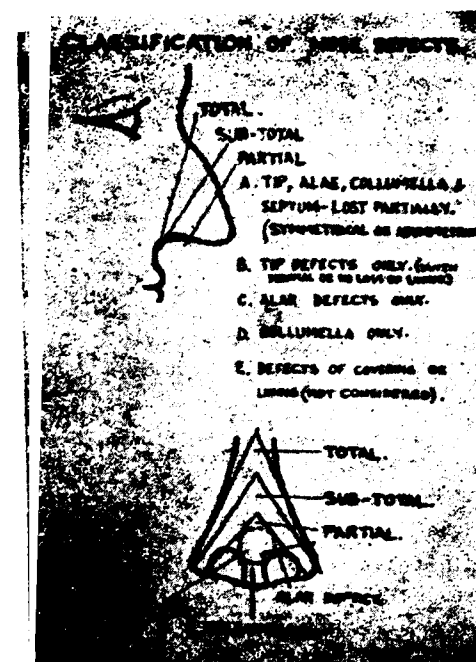


Fig. 1

A. *Total Loss*.—Loss of nose including septum and the nasal bone in part or whole (Fig. 3-A).

B. *Sub Total Loss*.—Nasal bone is intact and there may be part of the septum present. This may be:

- (i) Symmetrical (Fig. 2, A, C, D) or
- (ii) Asymmetrical (Fig. 2, E, F, G, H).

C. *Partial Losses*.—This has been further sub-divided into—

(a) Loss of tip, alae, columella or septum in part:

- (i) Symmetrical (Fig. 3, B, C, D, E)
- (ii) Asymmetrical (Fig. 3 F).



Fig. 2—Examples of Sub-Total Defects

B, C & D: Examples of sub-total symmetrical loss. E, F, G & H: Examples of sub-total asymmetrical loss.

(b) Loss of tip only with minimal or no loss of lining (Fig. 4 C, D).

(c) Loss of ala - (i) Partial (Fig. 4A) or
(ii) Complete (Fig. 4 B).

(d) Loss of Collumella only (Fig. 4 E, F).

(e) Loss of covering, lining or both (Not considered in this discussion).

Therefore their distribution has been as follows:



Fig. 3

Examples of Nose Defects

- A : Total loss of nose (incidentally includes loss of upper lip also).
B, C, D & E : Examples of symmetrical partial losses.
F : Shows asymmetrical partial loss.



Fig. 4

Examples of Partial Losses

- A : Partial alar loss.
B : Total alar loss.
C & D : Loss of tip only.
E & F : Loss of collumella 'E' shows reconstruction from skin of dorsum of the first web space of hand.

I. Defects of Nose Only

			Number of Cases.
1. Number of Total Loss	...	...	3
2. Number of Sub-total Loss	...	...	20
(a) Asymmetrical	...	6	
(b) Symmetrical	...	14	
All asymmetrical defects were made symmetrical before repair.			
	TOTAL	20	
3. Partial Losses	...	...	40
(a) Asymmetrical	...	11	
(b) Symmetrical	...	21	
(c) Tip defect only	...	1	
(d) Alae defects :—			
Complete	...	5	
Partial	...	1	
(e) Collumella	...	1	
	TOTAL	40	

II. Combined Defects of Nose and Upper Lip (See Fig. 5) ... 8

(a) Total nose and upper lip	...	...	2
(b) Total nose and partial lip loss	...	...	1
(c) Sub-total nose and partial lip loss	...	...	2
(d) Partial nose and partial lip loss	...	...	3
	TOTAL	...	8

GRAND TOTAL ... 71

Methods of Repair Results and Discussion

Out of the various methods described and known for Rhinoplasty, the author has mainly restricted to forehead flaps. Arm tube pedicles and couple of pedicles from the abdomen were also used for repair.

In the earlier stages for total reconstruction of nose, abdominal tube pedicles were tried while for subtotal or partial losses in

the case of females mostly, arm tube pedicles were employed as most of them did not like their foreheads to be spoiled. Lateral forehead, lateral temporal and sickle flaps were tried in some but due to various reasons all of them have been discarded and repair by median forehead flaps (Indian Method) was started. Now it has become the usual routine in every case, unless there are any contraindications.

I. Repair by Distant Flaps or Tubes

1. *Abdominal tube pedicle.*—Repair by this method has been tried only in 2 cases, and that too for total losses of the nose. Figure 6 clearly illustrates the procedure. It was experienced that repeated staged procedures were required. It was essential to put in cartilage pieces from the ear to form proper shape of the ala and an 'L' piece was also necessary in order to provide a bridge and proper support. Trimming and further thinning of the reconstructed nose was felt necessary later. Although there was a reasonable shape ultimately but the colour after all these stages was very dark and in contrast to the rest of the face it was no match. It does improve after a year or so but still it is never acceptable. Therefore, no further reconstructions of noses were planned by this method.

Dermabrasion as has been described by some for improving the colour has not been tried by the author.

2. *Repair by Arm Tube Pedicles* were tried in a total of 16 patients of which one was that of total loss of nose including the whole of the upper lip as in Fig. No. 5 A, B. Unfortunately this patient did not turn up for the next stage operation.

Seven cases of sub-total losses of noses were reconstructed by this method of which 2 had symmetrical defects, while 6 of them had asymmetrical defects. One of these had lip defect also where both the upper lip and nose reconstruction was tried by a single arm tube pedicle flap in four stages. All these asymmetrical defects in sub-total losses were converted into symmetrical defects before immediate reconstruction. One of them did not turn up for final repair as she was pregnant.

Six patients were treated for partial losses of the nose of which four were symmetrical and two asymmetrical and they were both converted into symmetrical defects before repair. In one of these final repair could not be done as the patient absconded.

In 13 Rhinoplasties, therefore, done by this method one was done as a second operation as the forehead flap had necrosed while in one primary reconstruction (Fig. No. 7) the flap necrosed after the nose had been reconstructed. If one sees her photograph it



Fig. 5

Examples of Combined Defects of Upper Lip and Nose

A & B: Reconstruction of both planned by a long arm pedicle.

E & F: Example of loss due to Lupus. This boy wears prosthesis for the last three years and is still under observation. No reconstruction should be attempted unless the disease is completely eradicated.

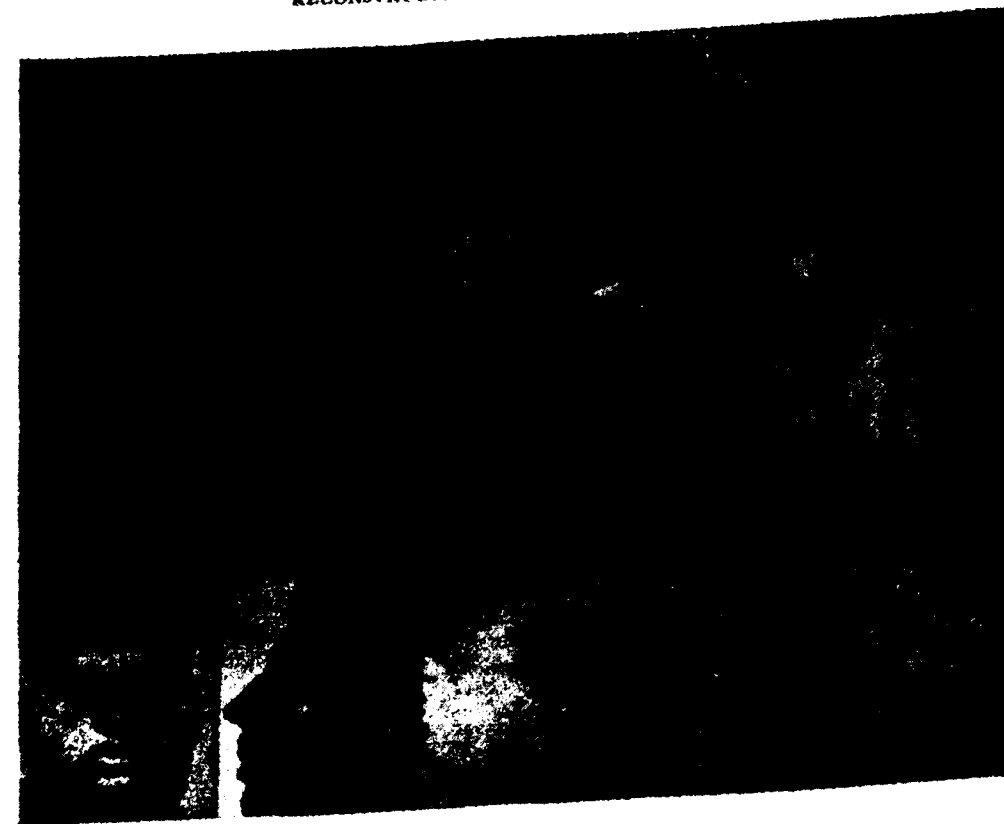


Fig. 6—Shows Steps of Total Rhinoplasty
By abdominal tube pedicle and cartilage graft for the nose bridge and alar support.



Fig. 7

Example of repair of partial defect by an arm tube pedicle. Necrosis occurred due to wrong fixation of the forearm. The same tube was utilized for reconstruction in a reverse manner. The colour improved in due course of time but there was some atresia of the nostrils.

is obvious that the fixation of the forearm to the forehead was wrong which resulted in a drag on the tube. The forearm if fixed across the forehead with internal rotation will produce this condition and one will have to constantly support the tube against gravity. This mistake was rectified in all other cases by fixing the forearm over the forehead and head and the hand resting on the occiput with full external rotation at the shoulder joint in that position (see figure Nos. 9, 10 and 12). However, in this patient the same tube was re attached to the nose as a cover and the lining with collumella

was made after detaching it from the arm. This incidentally is the Italian Method while the author has tried the reverse in all i.e., to construct the lining, collumella and both the alae first and in the last stage the flap is cut and trimmed to the shape of the defect in the covering. Excepting in this case and in one where there was little necrosis (Fig. No. 8) that needed secondary suturing near the base there has been no true loss of the flaps.

The reconstructed nose in most of them had been bulky when examined soon after



Fig. 8

Example of reconstruction from the arm tube pedicle of a partial defect. Necrosis occurred at the corner, that required secondary suturing. Final result was pleasing and the colour match was good that improved in time.



Fig. 9

Example of reconstruction by arm pedicle. Immediate result shows a bulky nose. Colour improved later on.



Fig. 10

Shows repair with arm tube pedicle. Here the remaining portion of the covering skin has been sacrificed and the whole has been replaced by arm skin, so as to reduce the colour contrast. The whole reconstructed nose appears to be bulky and darker. It improved in due course.

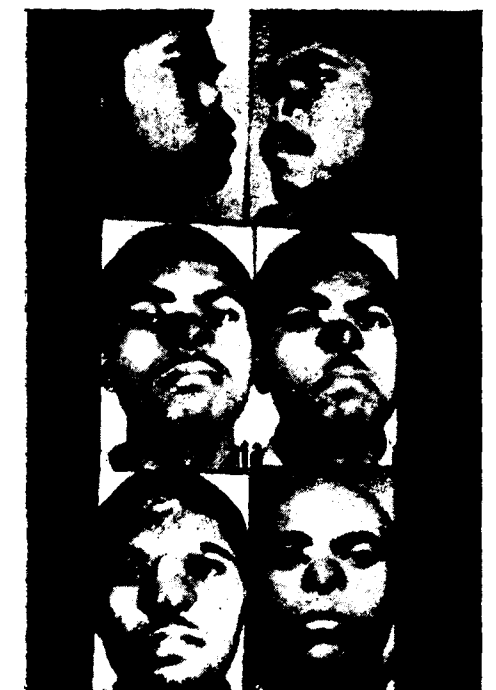


Fig. 11

Reconstruction of a defect due to some disease in childhood. (Similar to as in Fig. No. 10). The colour was very dark and hence midline forehead skin had to be provided for cover.

the repair but the over all results have been pleasing. Colour match had been dark in four patients (Figure Nos. 7, 9 and 10), that improved after a year in three, but the other one (Fig. 11) did not like it and had to be provided with midline forehead flap for cover. The colour difference in fairer females was not so marked (See Fig. No. 8 and 12). The size of the nose shrunk to a reasonable and presentable size in a year's time. 'L' shaped cartilage was not found to be necessary in any of them. Some atresia of nostrils resulted in two of these. It produced breathing difficulty in one (Fig. 11). It is felt now that in all such cases where reconstruction with an arm pedicle is planned even in sub-total losses one should sacrifice the original remaining portion of

the covering skin and replace it with single flap. This would provide a nose of one colour may be a shade darker than the original one as shown in Fig. Nos. 10 and 12.

Reconstruction of noses by arm tube pedicles so called the Italian method avoids disfiguring of the forehead while the colour match is not always upto the mark. The skin in texture is poor and the reconstructed nose shrinks considerably in time. Therefore, one has to plan a larger sized nose. Cartilage support is not always essential but as opposed to forehead flaps it becomes necessary to put a 'L' piece cartilage in most of the total losses of noses reconstructed by this method. Modelling of nostril is



Fig. 12

Shows a complete reconstruction with an arm pedicle. This brings out very clearly the point stressed in Fig. No. 10. The bulkiness reduces very much in due course of time.

supposed to be good by this method but the greatest drawback is that the finally reconstructed nose does never give the feeling of a nose to a palpating finger as it would to a forehead flap. Besides multiplicity or stages that increases the period of hospitalization of the patients, it means discomfort to them due to prolonged immobilization of the limbs and the head. In some instances these patients experienced difficulty in inspiration during breathing as the lining tends to fall and flaps due to its supple texture. Hence the use of arm or other distant flaps should be restricted for reconstruction of large losses of nose or combined defects of upper lip and nose, where it is not possible to reconstruct the lip by local arrangements or else, it should be used in a failed case of forehead Rhinoplasty. Finally one can also consider its use where patient is unwilling for forehead rhinoplasty or where the forehead skin is not considered to be suitable for one reason or the other.

3. *Post Auricular Flaps*:—Post auricular skin on a long tube pedicle in the neck is supposed to be the next best choice but here again due to limitations it cannot be utilized for large defects particularly of both lining and cover. This method, therefore, has not been tried in this series.

II. Forehead Flap Repairs

To avoid confusion in nomenclature they have been labelled as given in diagrams (Fig. 13-17).

1. *Lateral Temporal Flaps*.—Total rhinoplasties were not tried by this method. Out of 4 cases of sub-total losses repaired by this method one had asymmetrical defect that too was converted into symmetrical at the time of repair. Only one case of partial symmetrical defect was reconstructed by this method.

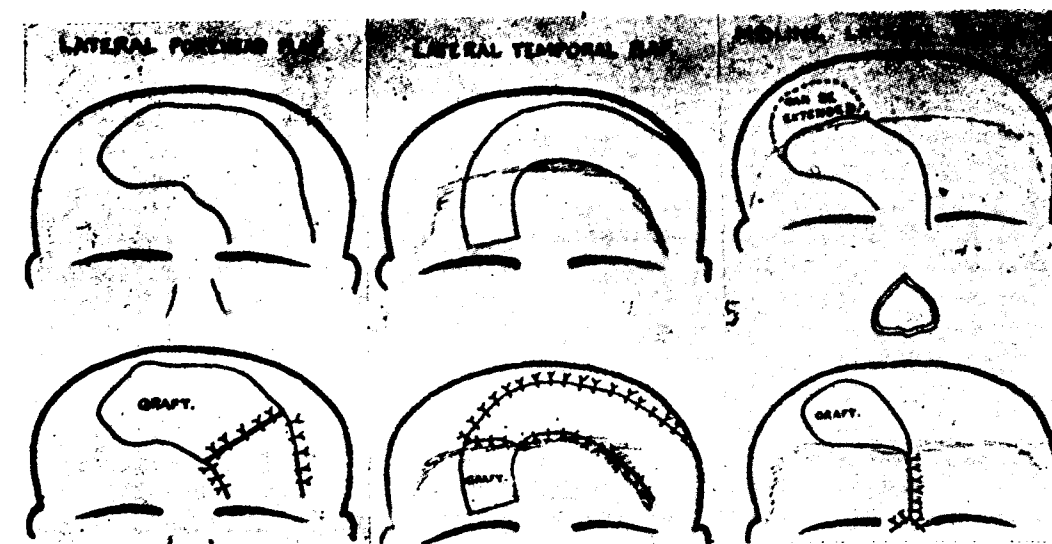


Fig. 13

Fig. 14

Fig. 15

Fig. 13—Plan of Rhinoplasty with lateral forehead flap.

Fig. 14—Plan of Rhinoplasty with lateral temporal flap.

Fig. 15—Plan of Rhinoplasty with midline lateral flap.

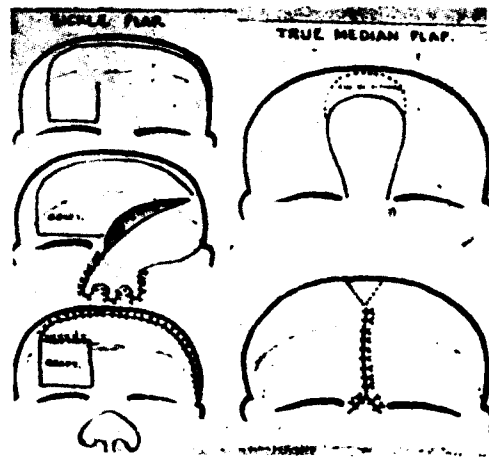


Fig. 16

Fig. 17

Fig. 16-Plan of reconstruction of nose with sickle flap.
Fig. 17-True median flap for nose reconstruction.

Therefore, in a total of 5 rhinoplasties done by this method one was reconstructed by Gillis method (Fig. No. 18) where nostrils are already formed and given a shape by implanting alar cartilage with auricular skin attached as free composite grafts at the first sitting. Author has limited experience of only two such rhinoplasties and is not impressed very much by the results as the final nose is rather a flat one because the septum cannot fully be made with a full columellar height.

In the rest the results have been good (Fig. No. 19). In all of them the forehead scar that was covered by a split graft was not very pleasing or satisfactory besides the fact that there were two parallel scars running in the hair lines. Further when this long flap is slid to the nose it tends to pull the reconstructed nose down (Fig. No. 20) along with gravity and has to be lifted or supported all the time. As advocated by some its use being made for reconstruction of the complete alar losses does not sound to be reasonable when other simpler methods are available.

2. *Lateral Forehead Flaps*.—Only one rhinoplasty was planned by this method for sub-total symmetrical loss (See Fig. No. 21) where a cartilage 'L' piece was put in the final stage. Although a good small, pointed nose is formed but it is too small in size and the greatest objection is, the big area of defect on forehead covered by split graft which is not satisfactory.

3. *Sickle Flap*.—Repair was done in 5 cases by this method (See Fig. 22) of which 3 were sub-total losses, while in 2 cases it was partial loss only.

Results invariably have been fairly good in so far as the nose was concerned but the forehead did show a patch of grafted skin. Besides this the sickle flap is too bulky although it avoids unnecessary scarring and



Fig. 18

Shows example of repair with lateral temporal flap by Gillis method.

produces only one scar line in the hair line that is easily hidden in the hairs. This can safely be practised in those who have big non-hairy area on the temples and where the hair line in the middle of the forehead comes closer to the eye brows.

4. *Midline Forehead Flaps or Median Rhinoplasty or Rininoplasty by Indian Method*.—Thirty-seven noses have been reconstructed

by this method. Therefore, their results will be discussed defect wise.

A. Total Losses

Two total nose reconstructions were done. In the very first case there was necrosis of the lining. The reason was a bad planning i.e. too much of lining was paid in and the covering was a tight fit. This strangled

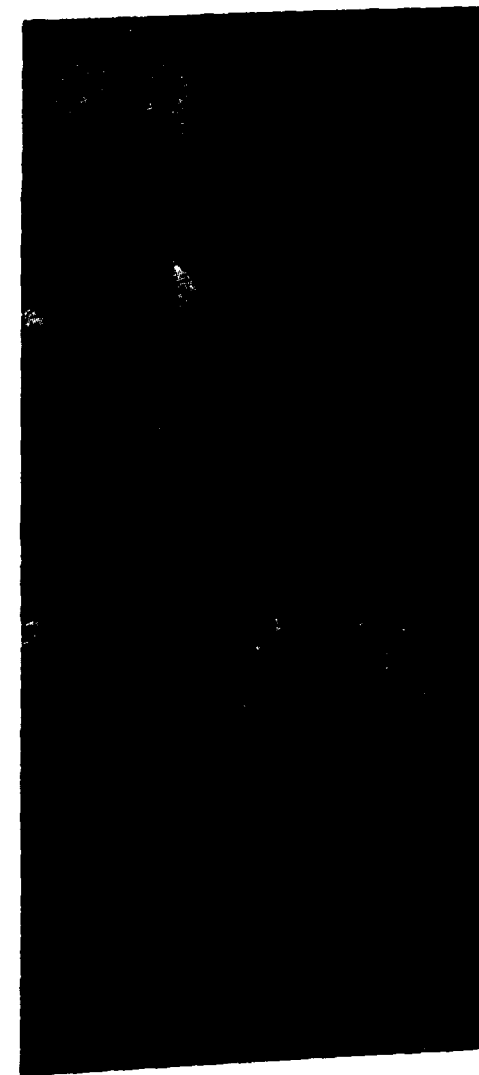


Fig. 19

Shows final result of repair with lateral temporal flaps in two patients.



Fig. 20

Illustrates the disadvantage of using lateral temporal flap that produces unnecessary drag on the reconstructed nose.



Fig. 21

Example of lateral forehead flap Rhinoplasty; 'L' shaped cartilage was used for the bridge of the nose.

some of the blood supply. It was, however, saved by putting in free grafts from the arm.



Fig. 22

Examples of Rhinoplasty with sickle flap.

The other patient had lateral 1/3rd of lip loss that was repaired by rotation flap but the nose reconstruction was excellent.

B. Sub-Total Losses

(a) *Asymmetrical*.—Two cases were reconstructed. They were all converted into symmetrical defects. In one (Fig. No. 11) it was simply used for cover as the nose reconstructed from arm tube was black. (Fig. No. 23) illustrates how big and long a midline flap can be designed and used for big reconstructions. Forehead triangular defect goes mostly in hair line but a part that remains on the forehead can be avoided by planning rotation flaps.

(b) *Symmetrical Losses*.—Five reconstructions were done for this defect. Fig. No. 24 shows a case with partial lip defect that

was repaired by local readjustment and auricular graft. Nose result was excellent and the forehead scar was also very good. Figure No. 25 and 26 also show excellent results obtained with this method.

C. Partial Losses

(a) *Asymmetrical*.—6 cases of partial losses were repaired by this method. Of these four were made symmetrical before repair. One of them is shown in Fig. No. 27. In another patient, as in Fig. No. 28 it was cut to fit the plan, in whom local re-arrangement and a composite graft from ear had failed on previous occasions. The result was satisfactory. In a third case of asymmetrical

defect (Fig No. 29, A and B), the plan reversed, however, enough skin was available for re-fashioning it. The result here too was fair. In all the rest of the patients the result has been excellent (See Fig. No. 29, C and D).

(b) *Symmetrical*.—Fifteen rhinoplasties were done by median flap. Two cases had additional lip defects. In one (Fig. No. 30) lip was repaired by Abbe flap and the nose by midline at the same stage.

Flap necrosed only in one case in whom the same fault was committed as in the first case of total rhinoplasty done by this method. Therefore, the nose was finally



Fig. 23

Illustrates a big sized midline forehead flap brought on a narrow pedicle.



Fig. 24

Midline Rhinoplasty for symmetrical nose defect and partial defect of the upper lip that was repaired by local arrangement of tissues and a post auricular graft.

made from arm tube pedicle. Figs. Nos. 31, 32 and 33 show some of the excellent results.

In thirteen cases, therefore, results were excellent in all except in one, in which it was good.

(c) *Alar Losses*.—Five cases of complete Alar defects were repaired by midline forehead flaps. The result was invariably excellent in three and good in two cases. Forehead Scar left a liner line (See Fig. No. 34).

(d) *Defect in the Bridge*.—Only 1 case came in this category who had intact alae, tip and collumella. Both lining and cover were provided by midline forehead flap (Fig. No. 35).



Fig. 25

Shows some of the excellent results by midline forehead Rhinoplasty.

Note : No cartilage support has been necessary in these cases.

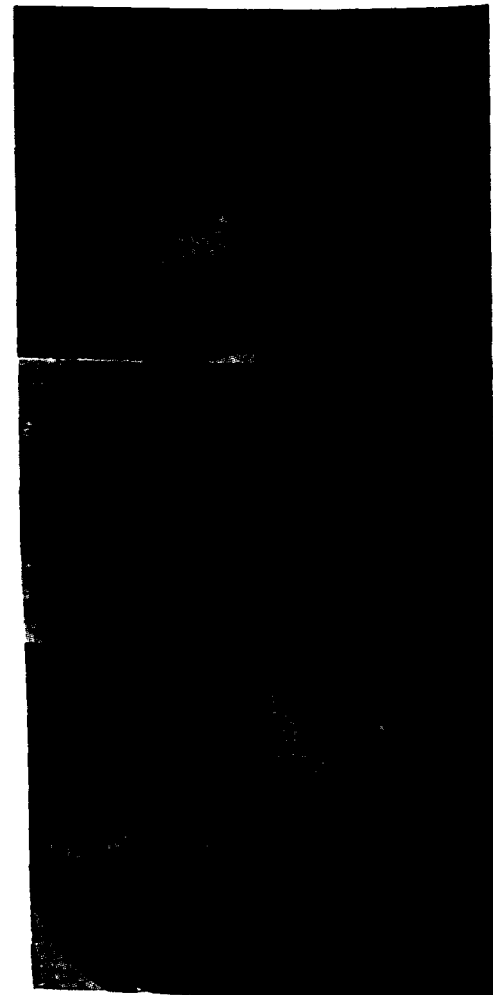


Fig. 26

Another example of midline forehead Rhinoplasty with excellent result.

Fig. 27

Same as 25 and 26. This patient insisted on piercing of left ala for wearing ornaments and she easily could cover her forehead scar by parting her hairs in different style

Fig. 28

Repair of partial asymmetrical defect by midline flap designed to fit the defect.



Fig. 29
Illustrates repair of partial asymmetrical defects utilizing midline forehead flap. In A, B. The plan got reversed (See text for details).



Fig. 30
Shows repair of combined defect of the upper lip and nose at the same sitting. Lip was done by Abbee Flap while nose was repaired by midline flap.

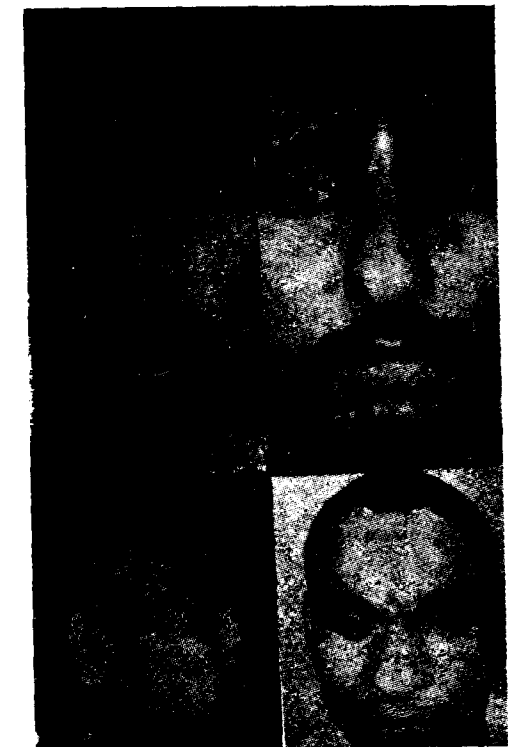


Fig. 31

Some excellent results of midline forehead Rhinoplasty for partial symmetrical defect.

Therefore, in a total of 37 midline rhinoplasties the forehead scar was liner and very pleasing in all the cases except in 5 out of which at the top there was a small triangular defect in 2 cases only that healed by scarring. The patients were very happy and did not bother as it could either be covered in their head of gear (Topi) or it could be hidden under the hairs. Only in 3 cases free partial thickness grafts were put in.

6. *Repairs by Midline Lateral Flaps*.—In 4 patients the midline flap was short in length, therefore, it had to be diverted to one side. There is no special advantage in this method as compared to the lateral flaps excepting for the fact that to some length the scar can be closed in one line instead of two scars and that the rest of the

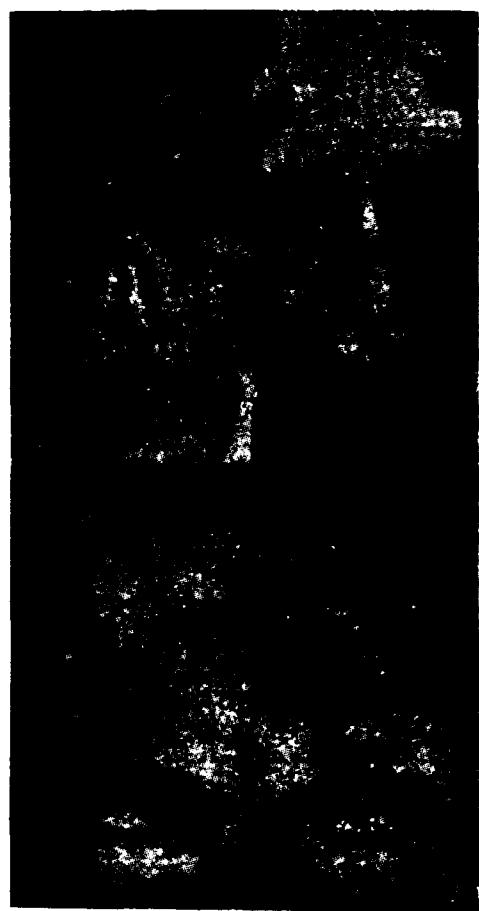


Fig. 32

Again shows some of the excellent results of forehead midline Rhinoplasty.

area has to be covered by a free graft. One was sub-total loss with satisfactory result. In this case too the lining necrosed due to some bad planning. The resultant nose was smaller and shrunken. The same flap was caterpillared and paid in to make good for the loss thus giving a satisfactory result (Fig. No. 36). Two were partial asymmetrical losses in this group the result was good in one and in the other it was pleasing (Fig. No. 37). The last patient (Fig. No. 38) had partial symmetrical defect with pleasing results. This patient came to us with a rhinoplasty tried somewhere else. The skin

was completely hairy. As an experiment epilation dose of radiation was tried. Then the nose was reconstructed with the same flap after suitable interval. Post-operatively epilation dose was repeated. The result was pleasing. In all excepting in one case forehead had to be covered with graft and the rest all healed by scarring that could be covered by hairs.



Fig. 33

Same as above.

Forehead flap in general gives by far the best results because of good blood supply, is easy to migrate and its use avoids prolonged immobilization of arm or head. It usually moulds to the shape of the nose,

therefore, cartilage supports are not really necessary (done in only one case in this series Fig. No. 21). One can plan a broader flap based on even a narrower pedicle. It has been said that the skin of the forehead is rather thick and does not fold over nicely to form the alar rim; but it has just been the contrary in the author's experience. It may leave unsightly scars on the forehead that is covered by poorly matched split thickness free grafts. This is more so visible in the case of males while females can always cover the region of the scar by

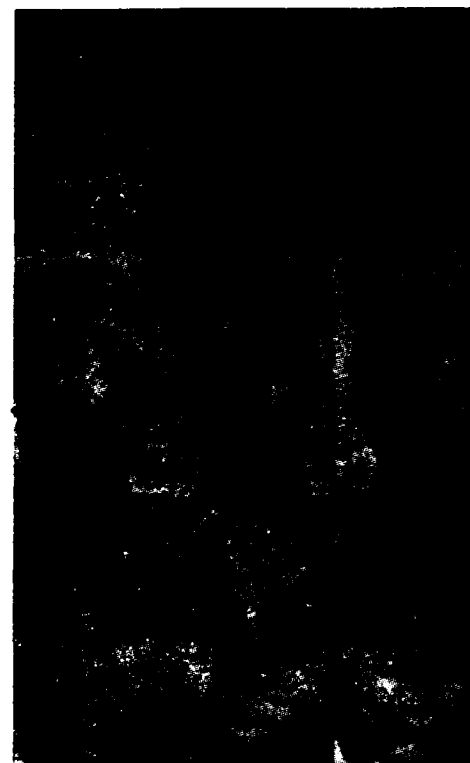


Fig. 34

Shows excellent results of reconstruction of partial or complete alar losses with midline flaps.



Fig. 35

Shows reconstruction of the losses of lining and cover both in the body of the nose.



Fig. 36

Example of repair by midline lateral flap owing to bad planning, size of the lining flap was bigger than the cover in breadth, that lead to partial strangulation and loss of lining, resulting into a shrunken nose. The remaining flap was caterpillared and was utilized at a later date to increase the size of the nose.



Fig. 37

Examples of repair by midline lateral flap with pleasing results.

changing their hair style. Scarring can be minimised by using sickle or median forehead flaps.

Forehead flaps have their limitations particularly if the forehead is very narrow



Fig. 38

Repair by Midline Lateral flap done somewhere else

Shows that the Surgeon only tried to just put lot of hairy skin of the forehead over the nose so as to give a bulk and epilation dose of radiation was given to the same flap as an experiment which was trimmed to the pattern of defect in two stages later. The flap survived exposures to radiation.

or the skin required for the coverage is not non-hairy. It has been felt that the hairy skin can be utilized for the lining and a few hairs on the collumella or even over the tip can be epilated by the patients. Doubts have been expressed by some Surgeons regarding hairs growing upwards in the reverse direction inside the nose. In author's experience no one has had any trouble on that account so far.

Repairs by the median flap so called the Indian method of repair is by far the best method. One to one and a half inches broad pedicles can easily be planned in between the eyebrows and the flap broadens as one ascends. Even it can be extended into the hair line for purposes of providing lining. Question of nonviability can be settled by following a set procedure i.e. first cut the flap according to plan, and see for brisk bleeding from the cut edges. Rotate it through 180° bring it to the site of defect. If there is tension one can further lengthen it by extending it to the root of the nose going outwards. If the twist is tight, one can cut across at its base to one side. Whenever during this manoeuvre if there is slightest doubt the flap can be re-stitched and delayed on the forehead.

Another great advantage of repair by this method is that the blood loss is minimal or negligible as compared to other types of forehead flaps. It can even be practised under infiltration of local anaesthesia. Blood is not necessary for transfusion and neither there is any need for hypotensive anaesthesia.

This can easily be employed on a patient who comes within first 24 hours of nose cut and thus he goes out of the hospital with a new nose in 3 to 4 weeks time.

Excepting for very narrow forehead to the author's mind midline forehead rhinoplasty is the answer for all types of major

defects both in males and females. A single scar in the forehead can be given even in the upper part by either stitching in the hair line in 'V'—'Y' fashion thus further advancing it forwards or else the flaps can be rotated from either side.

III. Repair by other methods

(c) Composite chondrocutaneous grafts—have been used in 2 cases only to repair the defects of tip in one and partial alae defect in the other with fairly satisfactory results.

(d) *Tube Pedicle* from the dorsum of first web space of the hand has been tried for defect of the collumella in one patient only with good result (See Fig. No. 4 E, F).

IV. Prosthesis

In only one case repair of the lip and nose has been deferred due to active Lupus of the face and nose and prosthesis given (Fig. No. 5, D).

Conclusions

1. Sixty-seven complete nose repairs of various types have been discussed.

2. True failure of primary repair occurred in three cases—two belonging to forehead flaps one median and the other midline lateral. One arm tube pedicle failed. Causes of their failure have been discussed.

3. Repair and their results by various techniques used have been discussed with their advantage and disadvantages.

4. Midline forehead rhinoplasty or repair by the Indian method is recommended wherever and when-ever possible as first choice for rhinoplasty.

5. Other alternatives have been discussed.

Acknowledgements

The author is grateful to his resident staff for compiling his data. His acknowledgement is mainly due to Dr. A. C. Ganguli, the Chief Resident and Dr. Kishan Chand, Dr. Nandi and Dr. K. N. Kapoor and the other residents for their cooperation and help. His thanks are also due to Messrs. Misra Studio for providing photographs and Mr. Hari Om D. Bhatnagar for typing his manuscript.

REFERENCES

1. Principles & Practice of Plastic Surgery—A. J. Barsky 1950 Edition.
2. The Surgical Treatment of Facial Injuries—Kazanjan—1944 Edition.
3. The Principles and Art of Plastic Surgery—Gillis & Millard, First Edition.
4. British Journal of Plastic Surgery, Vol. 13, No. 2, P. 98, 1960.

—Received for publication on 10-10-1961.

RECONSTRUCTIVE POSSIBILITIES IN EARLY REPAIR OF HAND INJURIES

BY

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The most important decision to be taken at the primary definitive treatment of a serious hand injury, is what to keep and what to remove. This decision has far reaching consequences. Removal is an irrevocable step. No subsequent reconstruction can be as good as building on what could have been preserved at the time of primary repair. But the removal of wreckage with no real reconstructive value is necessary to gain the valuable advantage of early healing with quick restoration of function in the remaining units of the hand (Fig. 1). Salvage of seriously injured parts of the hand involves a long programme of difficult reconstructive surgery. At the end of it all, the reconstructed units fall short of the normal in function and appearance. During the time taken by

various of the repair plan the hand as a whole cannot be actively exercised, and there is some impairment of function in the undamaged units also. Some of this impairment is liable to pass from temporary to permanent status.

There can be no brinkmanship in the treatment of a serious hand injury seen within the first critical six to twelve hours. Decisions cannot be shelved, because wounds pass from the relatively favourable stage of removable contamination to the more difficult phase of established infection. In the former stage, adequate cleansing, excision and repair can give good primary healing. This essential first objective is far less certain after established infection. If primary

healing fails, vulnerable structures like tendons and joints may suffer secondary damage and gross functional impairment. Early repair under proper conditions can do much to protect and preserve these structures which contribute most to useful function in injured hands. Time is therefore precious in this type of work.

Badly injured hands which come late with the possibility or certainty of established infection are difficult cases for salvage procedures. The chances of success are poor, but they should nevertheless be taken, if the alternative would be to lose the hand, or to leave it as a functionally poor appendage. We have reconstructed three thumbs out of such wreckage, and the results have been encouraging (Figs. 5, 6, 7).

The absolute indication for amputation is death of the part. As gangrene soon follows damage to the main vessels, this injury is often accepted as an indication for amputation. But wounds of large sized vessels can be sutured and the divided ends

of small arteries can be connected by polythene tubes to restore circulation for two or three critical days at least. The repaired or cannulated vessel may thrombose ultimately, but collaterals can be induced to open up in the main time, and the extent of death is minimised. This simple salvage procedure deserves to be considered in all early repairs of badly injured hands. In one case worth recording, a high speed power saw had cut through the proximal part of the palm, dividing all vessels, nerves and tendons on the radial and volar aspects and going through the bases of all metacarpals. (Fig. 2-a). The hand appeared obviously non-viable. Only the extensor tendons, veins and skin of the dorsum were intact. Circulation was restored by polythene connections from the ulnar and radial arteries to the corresponding cut ends of the superficial palmar arch. The hand survived, except for the distal two thirds of the thumb which had no intact arterial connection to the palmar arch (Fig. 2-b).

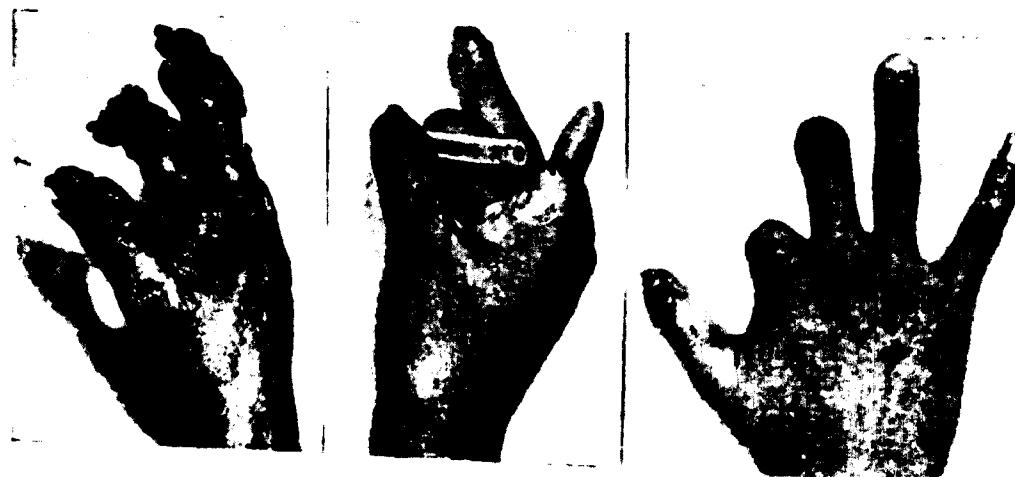


Fig. 1-a

Fig. 1-b

Fig. 1-c

Fig. 1-a—Severe crush injury of all digits except the little finger. Primary closure of wounds 4 hours later, after removal of all wreckage with no salvage value. The thumb needed a small sheet skin graft.

Fig. 1-b and 1-c—Result 3 weeks later. Good function.



Fig. 2-a

Fig. 2-b

Fig. 2.—D. B. P., M., 25, R. Hand.

Fig. 2-a: Power Saw injury through the bases of all metacarpals dividing all arteries. Primary repair 6 hours later with polythene tube connections restoring circulation.

Fig. 2-b—Result 6 weeks later. The thumb was lost, but the rest of the hand survived.

Skin Loss

The most common finding in serious hand injuries is skin loss. More hands are crippled by the secondary effects and complications of skin loss than by all other causes. The repair of skin loss is relatively easy, but the necessary plastic surgical procedures have to be carried out decisively and early to obtain all possible recovery of function. The methods available are—

1. Split skin graft.
2. Wolfe Graft.
3. Local Flap from the immediate vicinity of the defect.
4. Filletted Flap from a digit which cannot be saved.
5. Cross Finger or Palmar Flaps.
6. Abdominal, or pectoral flaps.

All these methods have their advantages and limitations.

The first four are single stage procedures listed in order of simplicity. Split skin grafts and Wolfe grafts are not satisfactory over exposed joints and flexor tendons. On the dorsum of the hand, split skin grafts generally do well, but on the palmar aspect, and in the webs, they tend to contract and need considerable after care on this account. Wolfe grafts do not contract, but their take is reliable only when the size is small, and the recipient area is clean and vascular. Local flaps are useful to cover small defects over vulnerable structures like tendons and joints. They are so planned that the secondary defects left on shifting them are at convenient sites and can be covered by split skin grafts, without leaving scars or tendon adhesions which limit function. A filletted flap is usually from a digit so damaged that removal is necessary. It is useful to cover defects in the adjacent part of the palm. If

it does not survive, the primary repair fails badly. Careful assessment of flap circulation and generous trimming of doubtful areas is therefore essential.

Flaps except from the immediate vicinity of the defect involve two operations at least, and a period of immobilisation between them. Palmar and cross finger flaps are often followed by stiffness of the finger because of immobilisation in positions of strain for the joints. These flaps are useful only for small defects of the tip or volar aspect of the digits, and such defects can be effectively covered in many cases by Wolfe grafts or even by split skin grafts. Flaps from the opposite forearm are sometimes tried, but it appears unnecessary to tie up both upper limbs when simpler methods are available. Extensive skin loss usually needs an abdominal or abdomino thoracic flap. When such flap cover is provided without delay, exposed tendons and joints have good chances of recovering useful function. In severe crush injuries all deep tissues are considerably devitalised, and circulation in damaged vessels is critical, or liable to become so by thrombosis. A primary abdominal flap not only restores skin loss, but also brings a new blood supply to the damaged part, helping devascularised tissues to survive (Fig. 3).

In late cases established infection has to be controlled by gentle but thorough cleansing and by antibiotics for 12 to 24 hours. Proper wound toilet and cover by an abdominal flap can then be undertaken (Fig. 7). Some necrosis of exposed bones and tendons may have taken place already but further loss is minimised by the vascular flap cover. Recovery of movement is unlikely in exposed joints covered late in this manner. Such joints should therefore be held in the position of best function during the healing period.



Fig. 3-a

Fig. 3-b

Fig. 3-c

Fig. 3-d

Fig. 3—E. L., M, 35. R. Hand.

Fig. 3-a—Severe crush in a cotton mill. Comminuted fractures of phalanges with cotton plugs wedged between fragments. Rupture of extensor expansions on index, mid and ring fingers.

Fig. 3-b—Primary repair 8 hours later: Debridement, setting of fractures, repair of extensor apparatus and creation of a surgical syndactyly between the three injured fingers to facilitate cover by abdominal flap.

Fig. 3-c, 3-d—Abdominal Flap to restore skin loss.

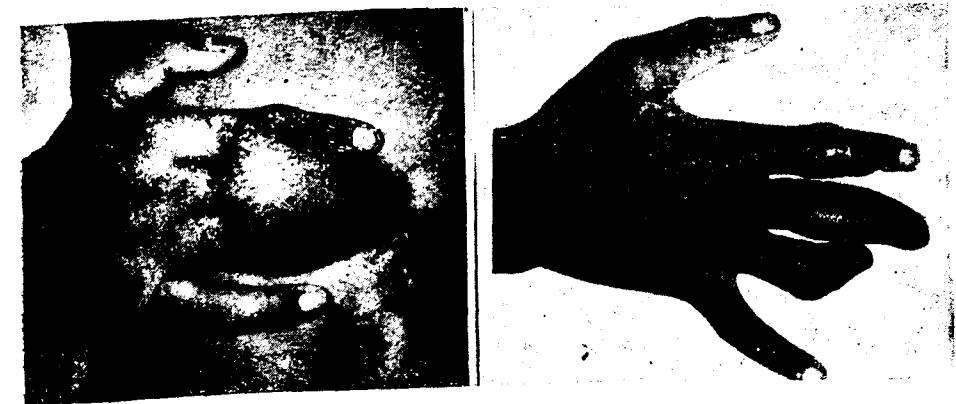


Fig. 3-e

Fig. 3-f

Fig. 3-e—Abdominal Flap to restore skin loss.

Fig. 3-f—Result after separation of the fingers (D-87)

Salvage Possibilities

Salvage procedures depend on two possibilities:—

A. Survival and revascularisation of autogenous tissues preserved *in situ* or grafted. For this the tissue must be viable, and placed in close contact with a vascular bed, free from infection.

B. Tolerance with subsequent encapsulation or colonisation by host tissues of implants other than viable autografts. For such tolerance, the field must be free of infection, and the implant incapable of exciting strong immune reactions leading to extrusion. Vascularity of the bed is of no particular advantage, except to deal with

initial infection at the site, where colonisation of the implant by appropriate host cells is not possible, absorption may be hastened by a rich blood supply at the site. Immune reactions are also more marked in vascular fields.

From the point of view of survival, if viable, and of tolerance, if dead, the skeletal core of a digit has good salvage potential. This is of the greatest practical value in the case of a detached thumb. Its skeletal core is dissected out and reattached to the stump and vascular skin cover is provided by an abdominal flap (Fig. 4). The result is good when the skeletal implant survives and revascularises retaining some joint mobility. If the implant is merely encapsulated with complete stiffness of the joints, the result is still superior to late reconstructions with nothing of the original thumb to build on. Sir Harold Gillies emphasised the great value of this primary

salvage procedure. We have extended its scope in a case where the crushed remnant of the thumb left nothing to salvage (Fig. 5). The index finger was also crushed through its base, and non-viable, but its distal two phalanges were good enough for salvage. The soft tissues were dissected off, and the bones with the intermediate joint intact, transplanted to the thumb. Under the primary skin cover provided by an abdominal flap, the transplant remained intact for some months, but showed almost total absorption after one year. In this case the injury was 10 hrs. old, and all cells in the implant were probably dead. The mineralised stroma was invaded by living host tissue, and gradually absorbed by a process of surface erosion. There is no true revascularisation in such cases.

Homografts of phalangeal bones may have a small place in reconstruction. With no skeletal support, the skin cover for a



Fig. 4-a

Fig. 4-b

Fig. 4-c

Fig. 4—D. D. B., M., 15. L. Hand

Fig. 4-a—Avulsion of the thumb while working on a drilling machine.

Fig. 4-b—Primary repair 8 hours later: Reattachment of the skeletal core with joint and tendon mechanism preserved.

Fig. 4-c—After primary cover by abdominal flap. Result at 6 months.



Fig. 5-a

Fig. 5-b

Fig. 5-c

Fig. 5—N. D., M., 20. R. Hand.

Fig. 5-a—Severe crush injury in a sugar cane press. Total loss of thumb and mid finger. Subtotal detachment through the base of the index.

Fig. 5-b and 5-c.—Primary repair 10 hrs. later. Transfer to the thumb of the salvage skeletal core from the index, and cover by abdominal flap. The implant absorbed mostly and a bone graft was added later.



Fig. 5-d

Fig. 5-e

Fig. 5-d—Bone graft at 4 weeks.

Fig. 5-e—Bone graft at 2 years, reduced to 50% by absorption.

thumb reconstruction shrinks when the hand is detached from the abdomen and the flap is relieved of slight intermittent pulls. It is difficult to accommodate a bone graft of adequate size after the flap settles down. In one case we used a coiled stainless steel spring as a spacer. It would be preferable to put in a homograft of the correct size and shape. In time it is bound to get absorbed, unless autogenous bone is in close contact with it and replaces it by a process of creeping substitution. To provide the best conditions for this replacement, large drill holes are made in the homograft as near as possible without disrupting the general shape and strength. The holes are packed loosely with autogenous cancellous chips. Thus the homograft is colonised with numerous foci of autogenous bone ready to invade and replace the foreign structure. This method is analogous to the practice of resurfacing an extensive burn with widely spaced strips of skin homograft, and subsequently filling in the intervals with strips of auto skin graft.

Survival of Special Tissues

We have very little data on the individual survival characteristics of certain irreplaceable elements of hand structures - pulp, nail bed, and digital joints. Each of these put in electively as an aseptic free graft, can survive under good conditions. But with the unfavourable antecedents of a serious hand injury, the survival of these units when salvaged, at the time of primary repair several hours later, is subject to four adverse factors :-

1. Direct damage, especially the element of crush.
2. The effect of strong antiseptics which are often applied as first aid.
3. Infection.

4. Progressive loss of vitality proportional to the delay between the impairment of circulation due to the injury and the reapplication of the salvaged part to a new vascular bed. Irreversible cellular death occurs steadily during the interval. In hot climates, the process is quite rapid. Local refrigeration of the injured part may offer possibilities, but it is hardly practicable in cases needing it.

It would be a great gain in any reconstruction, if the skin of the digit tip with its specialised structure and sensitive tactile organs could be preserved. We tried two experiments to test some possibilities.

In the first case, the distal phalanx of the thumb had been bitten through and was non-viable. The only connection was through the frayed strands of the flexor tendon, and the contused neurovascular bundle of one side. The vessels were thrombosed, but the digital nerve was intact. In the experiment, we dissected out the pulp skin carrying specialised tactile organs, left the digital nerve attached to it, and applied it as a free graft to the debrided end of the thumb. This was 8 hours after the injury, and the skin was grey in colour. At 24 hrs., it was pink suggesting early vascularisation. At 48 hrs. there were dark patches and the result looked doubtful. At 72 hrs. the graft was dead. Pus formed under it, and on the fifth day it was removed. Under better conditions with no infection, the graft could have survived. The tactile organs could have become functional after regeneration of nerve fibres through the contused segment of the digital nerve.

In the second experiment a finger crushed through its proximal phalanx was removed. The pulp and nail bed were left attached at the tip, but from the more proximal part

of the finger, soft tissues were removed, down to the skeletal core. The specimen was then implanted under the abdominal skin as a free graft, burying the phalanx down to the soft tissue cap, the rim of which was sutured to the lips of the abdominal incision. The object of the experiment, done 18 hrs. after the injury, was to determine whether the nail bed and pulp of the finger tip would vascularise and survive as a composite unit. The exposed finger tip sloughed, but the buried skeletal core appeared to be well tolerated.

Considering the great value of the specialised tissues at the finger tip it is worth

pursuing the search for such salvage possibilities under more favourable conditions.

Thumb Reconstruction

The functional value of the hand is vastly enhanced by reconstruction of the lost thumb. Even if the thumb is immobile and insensitive, it is of great utility as one essential limb of a holding mechanism, for grasp, pinch and stereognosis. Most reconstructive efforts aim no higher than providing such an apposition post. Where the skeletal core of the thumb cannot be salvaged, the primary repair normally aims to provide skin cover only. Due allowance has to be made



Fig. 6-a

Fig. 6-b

Fig. 6—J. L., M, 20. R. Hand.

Fig. 6-a—Severe blast injury due to gunpowder exploding in the hand. 8 inches of flexor pollicis longus was avulsed from the forearm, and the distal half of the thumb charred. Primary repair 12 hours later, preserving the bones and tendon. These were removed from under the abdominal flap when pus formed subsequently.

Fig. 6-b—Result 3 months after a bone graft to the thumb.



Fig. 7-a

Fig. 7-b

Fig. 7-c

Fig. 7—S. S. T., M, 40. R. Hand.

Fig. 7-a, 7-b—Gunshot wound through the base of the thumb admitted 40 hours late.

Fig. 7-c—Primary repair, 48 hours late. Salvage of skeletal core and abdominal flap cover. The implant was removed 8 days later due to sepsis. Repair completed with bone graft.



Fig. 7-d

Fig. 7-e

Fig. 7-f

Fig. 7-d, 7-e, 7-f—Result after transferring a Littler flap from the ring finger to endow sensation to the reconstructed thumb.

for shrinkage of the unsupported skin envelope. Subsequently a shaped cancellous bone graft from the iliac crest is introduced to provide skeletal support for the reconstruction. Such bone grafts survive, vascularise, and consolidate well. But they gradually get short by absorption from the tip, if the skin cover is insensitive. The process is analagous to the slow crumbling of phalanges in the insensitive fingers of leprosy, when the hand is put to rough use (Fig. 5-d, e).

on its neurovascular bundle. Such sensory endowment to a reconstructed thumb raises the hand to a higher level of function making stereognosis and skilled work within the range of practical possibility. We have done this with gratifying success in a case of gun shot wound of the R. hand with loss of the thumb received 24 hours late with established infection (Fig. 7).

Summary

Badly injured hands offer great scope for primary salvage procedures. These succeed best when done early. In every hospital such cases are delayed needlessly in their transit from the casualty service to the point where they receive definitive treatment. Where surgeons trained in this type of reconstructive work are available, such cases should be rushed to them with emergency priority.

REFERENCE

Rank, B. K. and Wakefield, A. R.: Surgery of Repair as applied to Hand injuries. Second Edition, E. & S. Livingstone Ltd., 1960.

—Received for publication on 5-1-1962.

ASSOCIATION NOTES

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THE XXIV ANNUAL CONFERENCE

The XXIV Annual Conference of the Association of Surgeons of India will be held at Calcutta during the last week of December, 1962. Dr. K. K. Ghosh, M.B., F.R.C.S., 33-B, Landsdowne Road, Calcutta-20, is the Local Secretary, who is making arrangements for the Conference. At the Conference the following subjects will be discussed :

1. Tumours of Urinary Bladder.

by Drs. K. K. Ghosh and H. K. Sarkar, Calcutta.

2. Management of Burns.

by Dr. Anjali Mukherji, Calcutta.

3. Symposium on Extracorporeal circulation for Cardiac Surgery.

(Initiated by Prof. A. K. Basu and Prof. P. K. Sen) with Guest speakers.

4. Septic and Suppurative Arthritis of the hip.

by Dr. B. Mukopadhaya, Patna and Dr. N. D. Aggarwal, Patiala
and

5. A Paper on Anaesthesia.

Besides this a few short papers will be presented. Members desirous of reading short papers are requested to let the Office know about the titles of their short papers well in advance (before the 30th of June, 1962).

Titles of Sectional Short papers should be intimated to the Secretaries of the various Sections before the above date. The names and addresses of the Secretaries of the Sections are as follows :—

1. Thoracic Section.

Dr. N. Gopinath, M.S., F.A.C.S., Department of Thoracic Surgery, Christian Medical College, Vellore (S. India).

2. Orthopaedic Section.

Dr. B. Mukopadhaya, M.Ch.Orth., F.R.C.S.E., Khuda Bux Library Road, Patna-4.

3. Plastic Surgery Section.

Dr. N. H. Antia, M.B., F.R.C.S., Ben Nevis, B. Desai Road, Bombay-26.

4. Urology Section.

Dr. B. N. Colabawalla, F.R.C.S., Ben Nevis, B. Desai Road, Bombay-26.

Railway concession certificates for attending the above Conference at Calcutta in December, 1962 will be available at the Head Office at Madras, from the 1st October to the 30th of November 1962.

* * *

SUBJECTS FOR DISCUSSION AT FUTURE MEETINGS

25th Meeting (1963)

1. Hypothermia.

2. Experiences in Surgery for Chronic Pancreatitis.

by Dr. R. S. Gupta.

26th Meeting (1964)

1. Non-tuberculous Intestinal granulomas.

by Drs. A. Prakash and S. K. Nair, New Delhi.

2. Surgery of Leprosy.

by Drs. N. H. Antia, Bombay and Paul Brand, Vellore.

* * *

NOTICES

UROLOGY SECTION

The Sectional Conference of the Urology Section of the Association of Surgeons of India will be held on the 17th and 18th of August 1962 at Vellore (S. India). Members of the Urology Section and all members of the Association of Surgeons of India are requested to attend this Conference.

Dr. H. S. Bhat, M.S., Professor of Surgery, Christian Medical College and Hospital, Vellore, is making the necessary arrangements for this Conference and members desirous of attending the Conference are requested to contact him early (before 15th June 1962) for accommodation, etc. at Vellore during the Conference.

ORTHOPAEDIC SECTION

Foreign Fellowship of the Orthopaedic Section of the Association of Surgeons of India Sponsored by Smith and Nephew

The Orthopaedic Section of the Association of Surgeons of India invites applications for the above Foreign Fellowship from young Orthopaedic Surgeons who must be members of the Orthopaedic Section of the Association of Surgeons of India.

There is one Foreign Fellowship for a Junior Orthopaedic Surgeon of the level of the Junior Consultant in the National Health Service, U. K. The tour will be of six weeks duration.

The candidate should apply to Dr. A. K. Talwalkar, M.Ch., Orth. (I.P.C.I.), F.R.C.S. (Eng.), 395, Lamington Road, Near Naz Cinema, Bombay-4. Six copies of the application containing all the information about their carrier, qualifications, experience, mentioning any distinctions which they obtained, their under-graduate and post-graduate work done and the posts held should be sent, research work done by them should be mentioned. Names of two referees should be given. The candidate must clearly state what special work he is interested in seeing U. K. and the Continent. He may indicate the centre where he would like to work in U. K. or on the Continent.

The fellowship will enable the candidate to visit one centre mainly to see specialized work like hand surgery or hip surgery in the above period. The candidate if selected will have to proceed on the tour by the 1st week of September 1962. The candidate will have to do all the correspondence with the centre where he wants to work. He will also have to arrange about his passport and other necessary things for foreign travel.

The Orthopaedic Section of the Association of Surgeons of India will give him Rs. 5,000/- for this Foreign Fellowship.

The last date of application is 20th June 1962.

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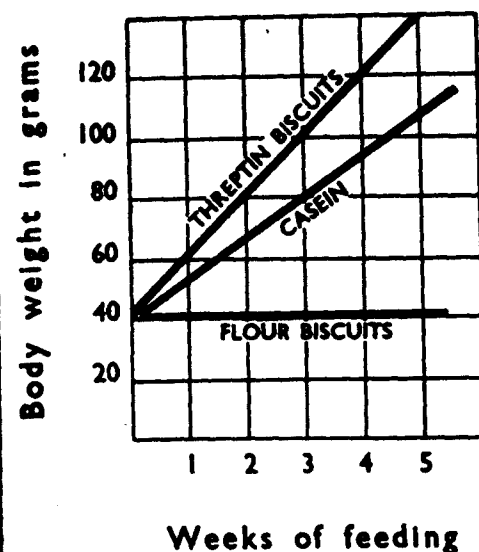
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