



Techniques of liver transplantation

During the last few years, technical improvements have been made in the performance of liver transplantation which have brought the procedure within the capability of many competent general and vascular surgeons. In this chapter the various aspects of this still complex operation are discussed with emphasis on those recently clarified details which stand above others in importance and significance. A more general account of liver transplantation is provided elsewhere in this text (Ch. 118) by Professor Roy Calne of Cambridge whose own work has profoundly influenced this field (Calne et al 1979, Calne 1983).

THE DONOR OPERATION

Without a well-preserved and properly functioning liver, orthotopic hepatic transplantation is an exercise in futility. In most countries, almost all transplanted livers are removed as part of a multiple organ procurement which can be performed easily in brain-dead donors without jeopardizing any of the grafts (Starzl et al 1984a). In fact, a lower rate of acute tubular necrosis of renal grafts has been recorded by several groups after multiple organ procurement than after donor nephrectomy alone (Shaw et al 1982).

The technique of multiple organ removal must be learned in a systematic way in heart-beating cadavers, using techniques of haemostasis and tissue handling which are no different from those in patients who are expected to survive. However, once the techniques of organ extirpation and cooling are learned in this way, a 'fast' method may be used which is based upon the same principles. Both the conventional and the rapid methods will be mentioned here in that order.

The standard operation

A midline incision is made from the suprasternal notch to the pubis (Fig. 121.1). After it has been verified that the liver has normal consistency and colour, the left triangular

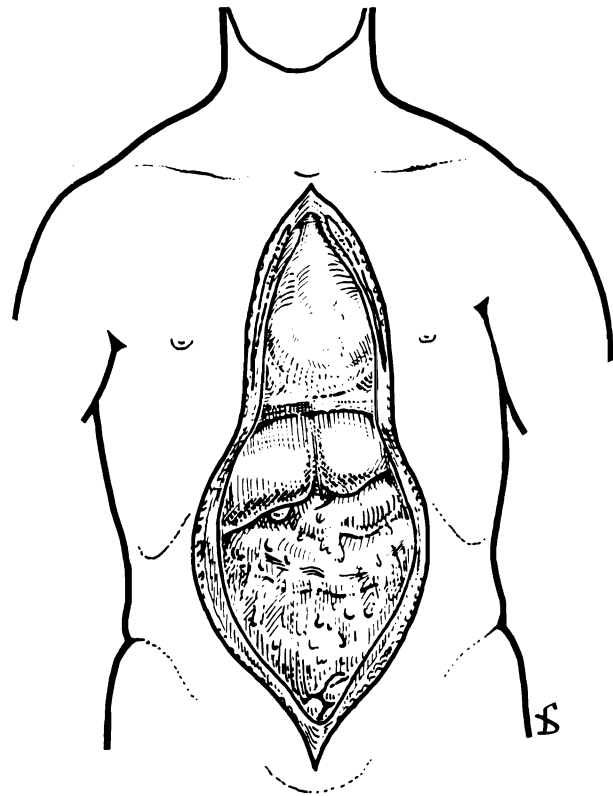


Fig. 121.1 Total midline incision used for multiple organ procurement. Reproduced with permission from Starzl et al 1984a

ligament is incised. Before anything else is done the aorta is encircled just above or at its passage through the diaphragm. This step allows the efficient infusion of cold solutions into viscera below the diaphragm at a later time.

Incision of the left triangular ligament allows the left lobe to be retracted to the right, thereby exposing the upper part of the gastrohepatic ligament. An hepatic arterial branch from the left gastric artery is looked for in this portion of the ligament and, if present, it must be preserved in continuity with the main left gastric artery and the coeliac axis (Fig. 121.2). The other anomaly which always is looked for is a right hepatic artery (or sometimes

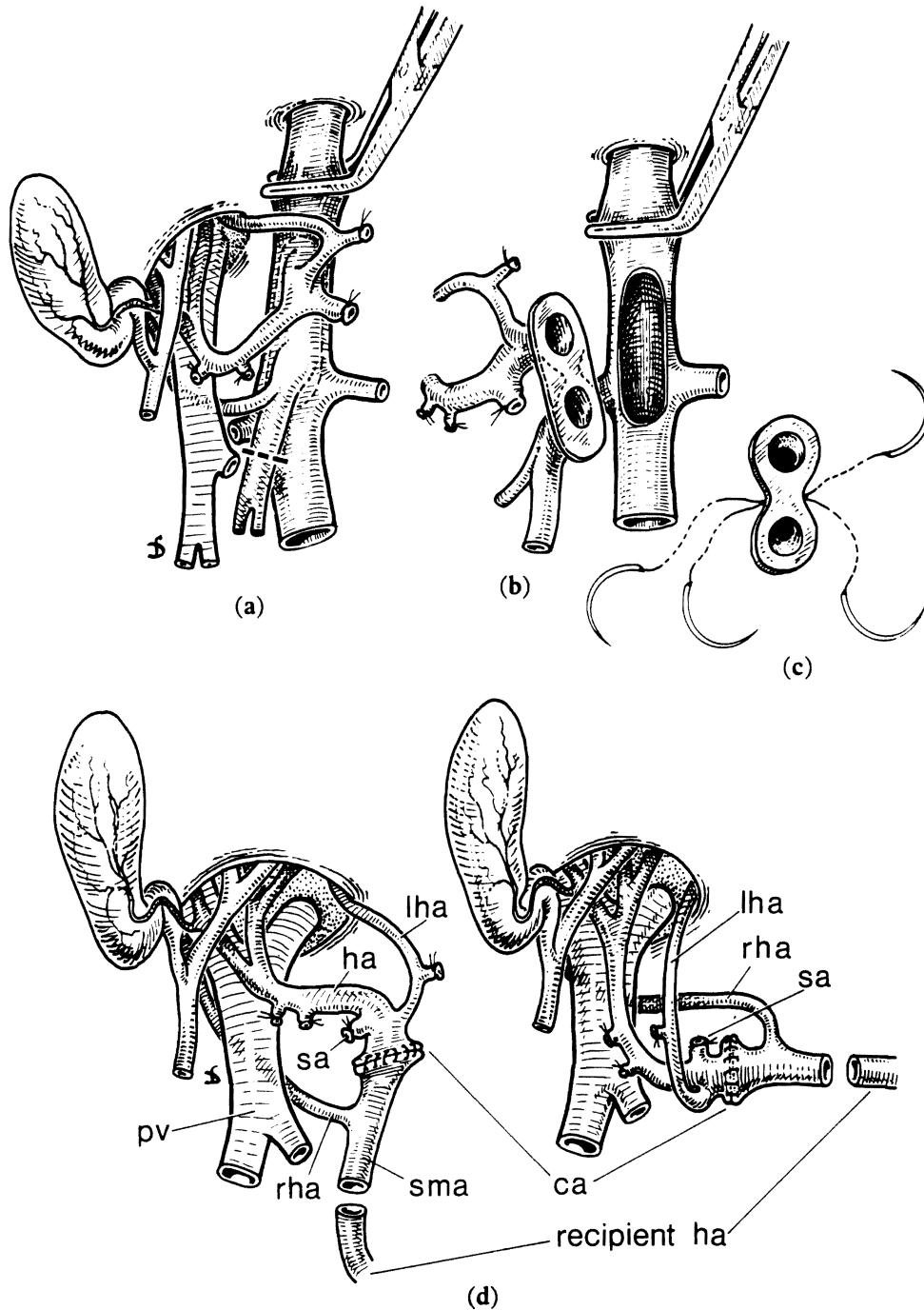


Fig. 121.2 Methods used to reconstruct a complex donor anomaly: (a) Split arterial supply to the liver originating from the left gastric, coeliac and superior mesenteric arteries. (b) A patch of anterior aorta including the origins of the coeliac axis and superior mesenteric artery is removed. The renal artery orifices are protected. (c) Folding of the aortic patch permits safe anastomosis of the coeliac axis to the superior mesenteric artery. (d) The superior mesenteric artery distal to the right hepatic artery is used for anastomosis to the recipient artery. The reconstructed arterial supply of the graft may be rotated to match the orientation of the host vessel. Reproduced with permission from Gordon et al 1985

the only hepatic artery) arising from the superior mesenteric artery. Anomalous vessels originating from the superior mesenteric artery almost always lie posterior to the portal vein and cross from the left to right, after originating at 90° from the main superior mesenteric artery (Fig. 121.2). In Fig. 121.2, anomalous hepatic arteries from both the left gastric and superior mesenteric arteries

are present in the same donor. Under such circumstances, the arteries can be brought together into a single trunk for anastomosis to a recipient artery (Fig. 121.2) (Gordon et al 1985).

If the hepatic arterial blood supply is normal, such complex manoeuvres are unnecessary. The splenic artery and left gastric artery are ligated and divided. More

distally, the right gastric and gastroduodenal arteries are also ligated and divided. If this succession of steps is followed (Fig. 121.3), subsequent dissection of the common duct and the portal vein is rendered relatively bloodless; otherwise, the richly vascularized pancreas and duodenum bleed throughout the dissection unless there are exhaustive efforts at haemostasis.

The common duct is transected as far distal as possible, and the gallbladder is incised, permitting the bile to be washed out (Fig. 121.3). Failure to remove this bile may lead to autolysis of the extrahepatic and intrahepatic bile ducts during the ischaemic period of storage with subsequent sludge formation.

The portal vein is now dissected inferiorly until the confluence of the splenic and superior mesenteric veins is reached. If the splenic vein is of large enough calibre, a cannula for subsequent infusion is placed into it (Fig. 121.3). As a final step, enough infrahepatic vena cava is cleaned so that the site of entry of the left and right renal veins can be seen with certainty. These landmarks are required to locate the place of future transection of the vena cava below the liver (Fig. 121.3).

The terminal aorta and vena cava are dissected free and encircled. If the kidneys also are to be removed, the ureters can be detached from the bladder and mobilized. After total body heparinization, a large bore cannula is placed in the distal aorta through which cold preservation fluid will be infused (Fig. 121.4). A large cannula may be

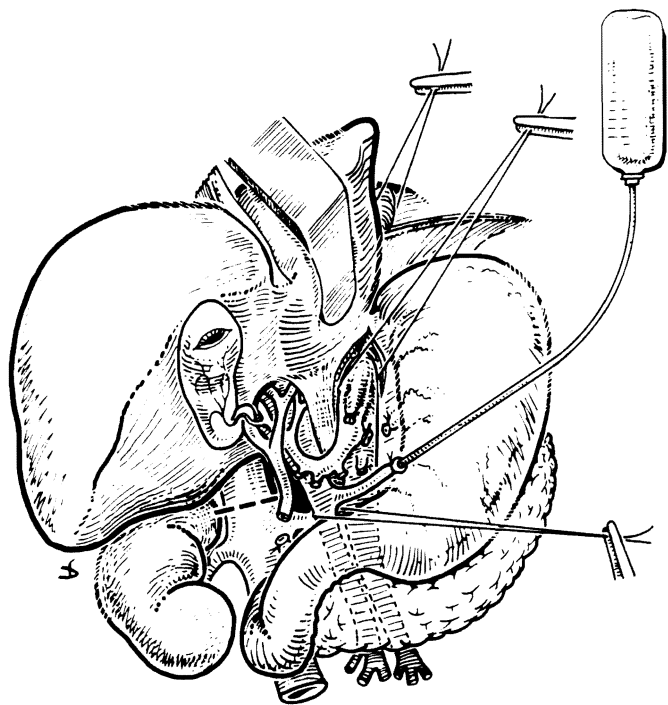


Fig. 121.3 Hepatectomy: hilar dissection and transection of the common bile duct as an initial step in multiple organ harvesting. Note that the splenic vein (or alternatively the superior mesenteric vein) is cannulated for eventual delivery of preservation fluid. Reproduced with permission from Starzl et al 1984a

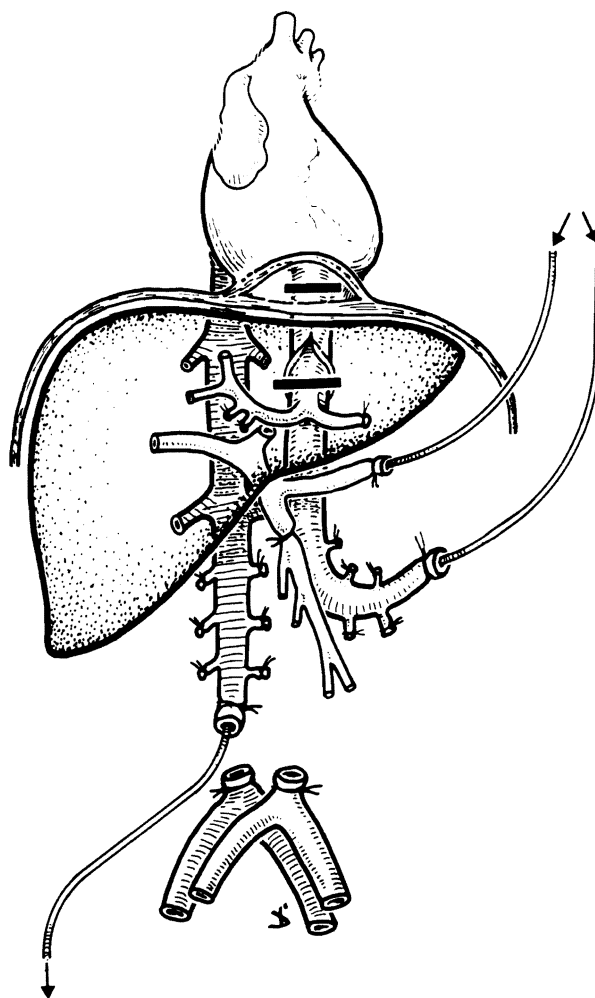


Fig. 121.4 In situ infusion technique used when the kidneys and liver are removed from the same donor. Infusion into splenic vein and distal aorta. Reproduced with permission from Starzl et al 1984a

placed into the inferior vena cava for eventual bleeding off into a bag on the floor (Fig. 121.4).

When all is in readiness, a moderately rapid infusion of lactated Ringer's solution into the portal system is started (Fig. 121.3, 121.4). If this infusion is done with caution, it does not jeopardize the patient's cardiodynamics, although the body temperature may slowly fall into the 30–32°C range. The liver can be felt to cool and when this is evident, or if the patient becomes unstable, the aorta is cross-clamped, and cold preservation fluid is introduced rapidly through the aortic cannula at the same time as the vena caval blood is allowed to drain out into the floor bag (Fig. 121.4). If the aortic cross-clamping at the diaphragm and the aortic infusion are carefully timed, warm ischaemia is eliminated for the kidneys as well as for the liver which is already partially cooled. The exact constituents of the preservation fluid infused into the aorta is probably not so critical as the timing just described. Most centres prefer

the potassium-rich Collins solution for cold infusion of the aorta and for a final infusion through the portal vein.

After the organs are cold, the origin of the coeliac axis is detached from the aorta, usually with a small Carrel patch. The portal vein is freed and the infrahepatic vena cava is transected. The liver is removed with a piece of diaphragm and with part of the right adrenal gland so that the right adrenal vein may be easily identified later.

The liver is immediately placed in a fluid-filled bag. The bag is packed in ice until the liver is taken out in the recipient's operating room for final dissection and removal of extraneous tissue in an ice basin on a back table. The kidneys which have been cooled in situ are removed in the conventional way, a process which is made easier by the absence of the overlying liver.

The fast method

Preparation of the liver and the preliminary steps for kidney removal in a heartbeating cadaveric donor require one and a half or two hours of an experienced surgeon's time or considerably longer than this in the event of unfamiliarity with the anatomy. Once the basic operation has been mastered, a modification of technique may become desirable (Starzl et al 1985b). With the modification, no preliminary dissection is done except for encirclement of the proximal aorta, and ligation and cannulation of the terminal aorta or one of the iliac arteries (Fig. 121.5). If the heart is to be removed, the cardiac surgeon is asked to proceed as if no other organs were involved, but with the proviso that a warning be given when effective circulation ceases. At that moment, the aorta is cross-clamped at the diaphragm, and an infusion of cold Collins solution is started in the distal aorta.

The liver becomes blanched and free of blood with surprising rapidity providing caval decompression is permitted by bleeding off into a bag (Fig. 121.4) or by incising an iliac vein. Within two or three minutes, the liver is palpably cold. At the same time the intestines become blanched, and blood in the portal vein becomes clear and haemoglobin-free (Starzl et al 1985b). Perfusion of the liver is thus assured via both the hepatic artery and the portal vein (Fig. 121.5).

In adults, two to three litres of cold Collins solution into the distal aorta are required to bring the liver to an acceptable degree of initial chilling. After this has been achieved, the aortic infusion is slowed down. The main vessels of the coeliac axis can be ligated swiftly and the hilar dissection can be completed in a matter of a few minutes. The portal vein is cleaned inferiorly to the junction of the splenic and superior mesenteric veins and these individual tributaries are divided. Lifting the portal vein anteriorly, promptly excludes the possibility of a missed right hepatic artery coming from the superior mesenteric artery (see Fig. 121.2). The liver is then excised with the same tech-

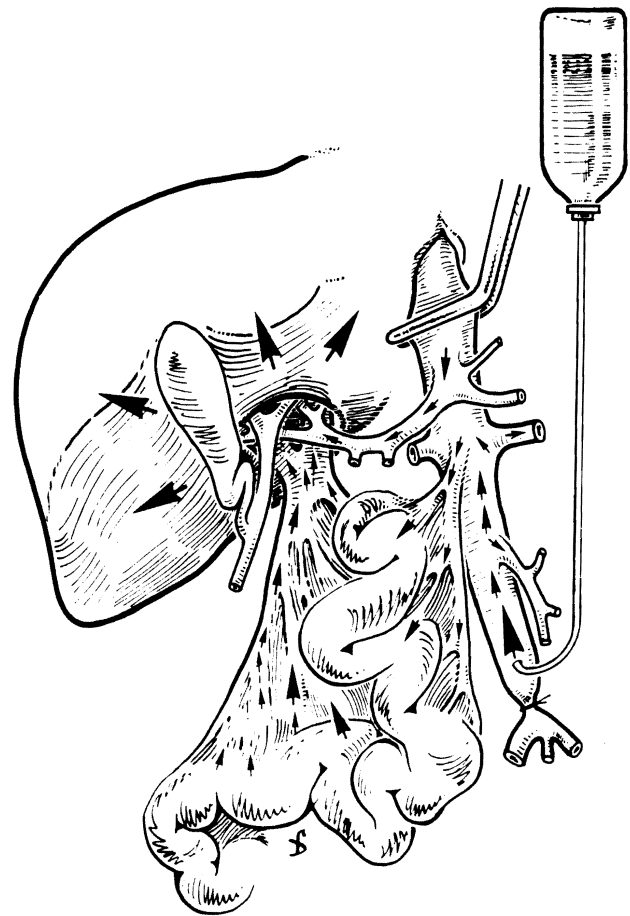


Fig. 121.5 Method of rapid liver cooling that can be done without any preliminary dissection except for insertion of a distal aortic cannula and cross-clamping of the aorta at the diaphragm. The infusion fluid quickly gets into the portal system via the splanchnic capillary bed, providing double inflow cooling. Reproduced with permission from Starzl et al 1985b

nique as previously described, leaving fragments of diaphragm and adrenal gland with the specimen. Infusion via the aorta of the kidneys can be continued slowly as nephrectomies are performed.

With the ability to perform all dissections in a bloodless field using the rapid method, it is possible to carry out multiple organ removal including the heart, liver and both kidneys in about half an hour. With this technique, satisfactory livers can be removed from donors with absent or ineffective heartbeat. This may be a necessary condition of liver harvest in countries which do not have 'brain death' laws. More commonly, the method can be used to terminate procurement quickly in patients who become unstable during 'standard' dissection.

The quality of the liver grafts with the rapid method is as good as with the more tedious standard operation. However, the disadvantage is that a much higher level of skill is required to do the rapid operation safely. The skill is automatically learned by prior experience with the standard procedure. With either approach, the integrity of the

surgeon performing the donor operation must be beyond question since failure to reveal information about technical surgical accidents or other problems may result in the surgeon operating on the recipient making an irrevocable decision to go forward with tragic results.

THE RECIPIENT OPERATION

The recipient procedure tends to be long and physically demanding. Its different parts are so remarkably dissimilar that a single surgeon operating from skin-to-skin may find it difficult to change emotional and intellectual gears to keep pace with the changing events. For example, removal of the diseased liver may be one of the most brutal and bloody experiences in a surgeon's life. Yet the subsequent performance of the vascular anastomoses can be amongst the most delicate and sophisticated, especially in very small children. The procurement of perfect haemostasis after the new liver has been revascularized is the next phase and is often a tedious exercise without which all that has gone before may be completely meaningless. And at the end, the biliary tract reconstruction becomes the final thread on which the whole enterprise is suspended.

Observers and counsellors often have suggested that various parts of the procedure should be done by independent and fresh teams. This may become an appropriate arrangement for the future. However, in the past and for the time being, in the training of a new generation, single surgeons have performed the procedure in order to be able to understand the entire operation and all of its ramifications. In fact, some subtle technical problems of liver transplantation could not have been clarified during the developmental period without having a single surgeon do both the donor and recipient procedures on a large number of occasions.

The incisions that can be used for the recipient operation are summarized in Figure 121.6. A right subcostal incision is almost always used, but its exact location is dictated by previous right upper quadrant incisions, and by the size and configuration of the liver. Extensions are also variable but an upper midline component has been particularly valuable if the xiphoid process is excised (Fig. 121.6). The xiphoid excision permits access to the hepatic veins and suprahepatic vena cava. Of lesser value is a left subcostal extension. In the majority of cases, the patients end up with a bilateral subcostal incision, with a superior midline T extension. Thoracic extensions are almost never needed.

Making the incision and obtaining exposure of the proposed operative field can be a major task, particularly if there have been previous right upper abdominal operations as is often the case. It may be necessary to abandon delicate conventional techniques of haemostasis with small haemostat bites and tying, and to resort to continuous

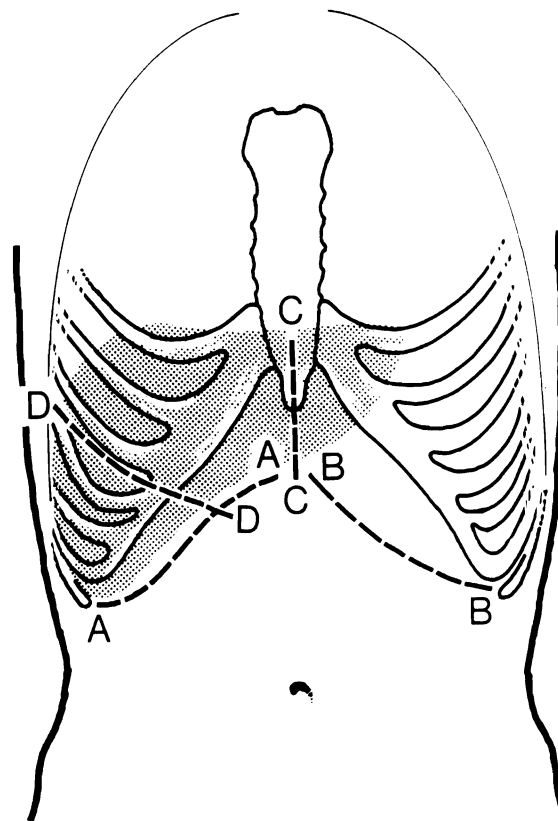


Fig. 121.6 Incisions for orthotopic liver transplantations. Note that several extensions may be made from the basic right subcostal incision, A to A, that is almost always used. More than one of the depicted extensions may be required in a given patient. Reproduced with permission from Starzl et al 1975

haemostatic sutures at the cut edge of the fascia and peritoneum, using a Prolene[®] suture which will slip easily through the tissues. Once the abdomen is entered, an effort is made to find a plane of dissection just outside the liver capsule. Movement away from this plane invites disruption of major varices which may be large enough to cause disastrous or even lethal haemorrhage during the preliminary dissection.

The recipient hepatectomy

There is no single best way to remove a diseased native liver. Once exposure has been obtained, it is important to assess the pathology and to decide upon whatever technical approach the basic pathology will permit. In some patients, efforts to mobilize the liver from the hepatic fossa can cause lethal haemorrhage unless the hepatic arterial and portal venous blood supply are ligated first. In others it may be absolutely impossible because of scarring or massive formation of varices to individually dissect the structures of the portal triad. A surgeon who insists upon following the same steps in unvarying order for all recipient hepatectomies will be doomed to a large number of

failures. Furthermore, the method of hepatectomy, as well as the conduct of the rest of the operation, are largely determined by whether or not veno-venous bypass is to be used.

The venous bypass question

When liver transplantation was first attempted in dogs (Moore et al 1960, Starzl et al 1960), survival was not possible without using a veno-venous bypass that transmitted blood without a pump from the inferior vena cava and the portal vein into the superior vena cava while the lower venous systems were obstructed during the anhepatic phase. Even though the time necessary to sew in the new liver was as brief as 30–40 minutes, the capillary beds were ruined by the venous hypertension without the passive bypass.

When the operation was performed in man, it was learned that such bypass was not an obligatory condition for survival (Starzl 1969) and was abandoned for almost 20 years. The disadvantages of using passive bypasses clinically were several. Placement of the tubing for the venous bypass was a nuisance (Fig. 121.7), the bypass tended to clot unless heparin was given, and, worst of all, the clots appeared to be the nidus of iatrogenic pulmonary emboli in some recipients (Starzl 1969). The use of heparin to prevent the latter complications caused uncontrollable hypocoagulability.

With no provision to decompress obstructed splanchnic and systemic venous beds, every liver replacement in patients was carried out in a crisis atmosphere comparable to that of open cardiac surgery under inflow occlusion. Time being such a precious commodity, an attempt was made before venous occlusion to skeletonize the diseased liver and to mobilize it as completely as possible. The object was to limit the occlusion time to that required for performance of the two vena caval and the portal anastomoses.

Even with such precautions, there was an intraoperative mortality of about 5%. The fact that the 95% could survive the venous occlusion gave a false impression about its adverse effects. In most patients, damage to the splanchnic and systemic capillary beds was grossly evident with petechial haemorrhages and with tissue swelling which was sometimes massive in the intestines. The development of third-space syndromes was common, in which massive quantities of fluid were first sequestered and later mobilized in the event of survival. The manipulations, including volume preloading in order to keep the patients alive during this stressful time, were a source of horror stories for two generations of anaesthetists.

Augmented haemorrhage was not the least of the problems caused by venous occlusion. Even though patients with endstage liver disease always have venous collaterals, many of these depend for ultimate decompression upon

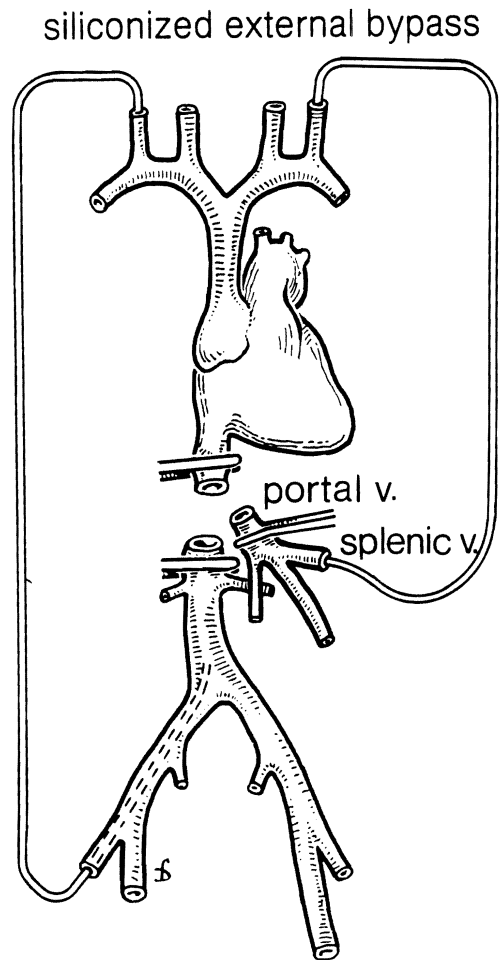


Fig. 121.7 One system of venous bypassing which was used in the early cases of clinical liver transplantation. Pulmonary emboli which developed in the tubing were the immediate or contributory causes of death in the first three patients who survived orthotopic transplantation. The clots in two of the patients originated at or near the site of insertion of the femoral catheter. Reproduced with permission from Starzl et al 1963

connections within the abdomen to the systemic venous system. With occlusion of both the vena cava and the portal vein, haemorrhage from the thin-walled varices and from all of the raw surfaces of the operative wound was predictably amplified. The bleeding often could not be controlled by any mechanical means until decompression occurred by opening of the vena caval and portal venous anastomoses.

In 1982 and 1983, a veno-venous bypass system without recipient heparinization was developed, tested in the dog model (Denmark et al 1983), and eventually brought to the clinic (Griffith et al 1985, Shaw et al 1984). An atraumatic pump was used with coagulation-resistant tubing (Fig. 121.8). It was found possible to carry out venous bypass for as long as four or five hours without obvious harm to the recipient. With this development, it became possible to modify all aspects of the recipient operation in adults, including the technique of hepatectomy. The

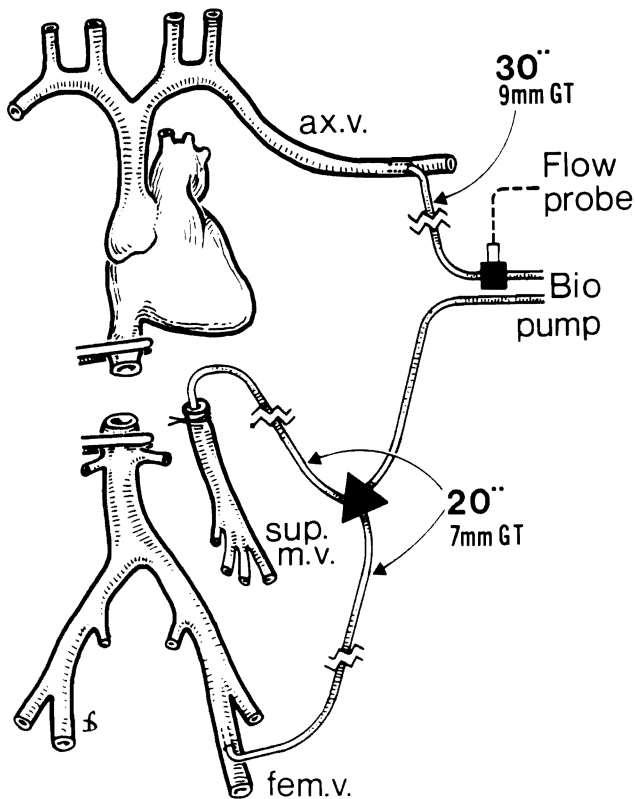


Fig. 121.8 Pump driven bypass. Reproduced with permission from Griffith et al 1985

following is a description of hepatectomy in a patient on bypass. More complete accounts of other details of hepatectomy can be found elsewhere (Starzl 1969, Starzl et al 1976).

Hepatectomy on bypass

The extent of preliminary dissection can be greatly decreased if the veno-venous bypass is to be used. The individual structures of the hilum usually are skeletonized, but no other areas need to be invaded. When the bypass is ready for implementation, the hepatic artery and the common duct are ligated. The portal vein cannula for the veno-venous bypass is inserted as well as a femoral cannula allowing both the splanchnic and systemic systems to be brought into the veno-venous circuit. Entry into the superior vena caval system usually is via the axillary vein (Fig. 121.8). In adults, one to six litres of blood per minute are bypassed. Simultaneous obstruction of the portal vein and inferior vena cava should cause little change in blood pressure or other measures of cardiovascular function under bypass conditions.

With the haemodynamic stability afforded by the veno-venous bypass, it is now possible to systematically divide all other structures which are holding the liver including the infrahepatic vena cava (Fig. 121.9). The triangular liga-

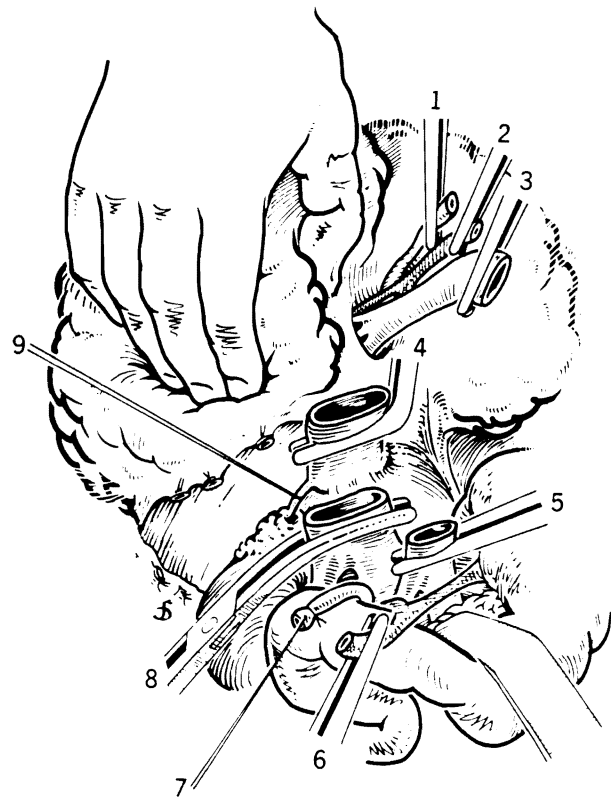


Fig. 121.9 Technique of retrograde removal of liver. Incisions. AA, subcostal incision used for all orthotopic liver transplantations. BB, CC and DD, frequently used extensions from the AA incision. (see Fig. 121.6) Beginning retrograde removal after transection of inferior vena cava and hilar structures. All posterior tissue that is cut should be ligated or sutured (see Fig. 121.11) although the named vessels encountered, such as the right adrenal vein (9), are few in number. Reproduced with permission from Starzl et al 1976

ments (if these have not been incised already), and the leaves of peritoneal reflection which make up the coronary ligament are cut (Fig. 121.10). The bare areas are entered on both the right and left sides (Fig. 121.10). After these manoeuvres have been carried out, the right hepatic lobe can be retracted into the wound and it is quite easy to encircle the inferior vena cava, either just below (Fig. 121.9) or above the liver, and eventually at both locations. The liver can then be shelled out on the stalk defined by the vena caval connection (Fig. 121.10C), and the vena caval cuff for eventual anastomosis can be developed (Fig. 121.10 D) (Starzl et al 1976).

Once the liver is out of the wound, it is possible using veno-venous bypass time to close all the raw surfaces that were created during the hepatectomy (Starzl et al 1985c). This is usually done with a continuous Prolene[®] suture, beginning at the tip of the right triangular ligament and continuing this centrally in rows that eventually are connected (Fig. 121.11a). The superior leaf of the coronary ligament can be the starting point and with continuation into the bare area itself (Fig. 121.a & b) and eventually to the inferior portion of the coronary ligament

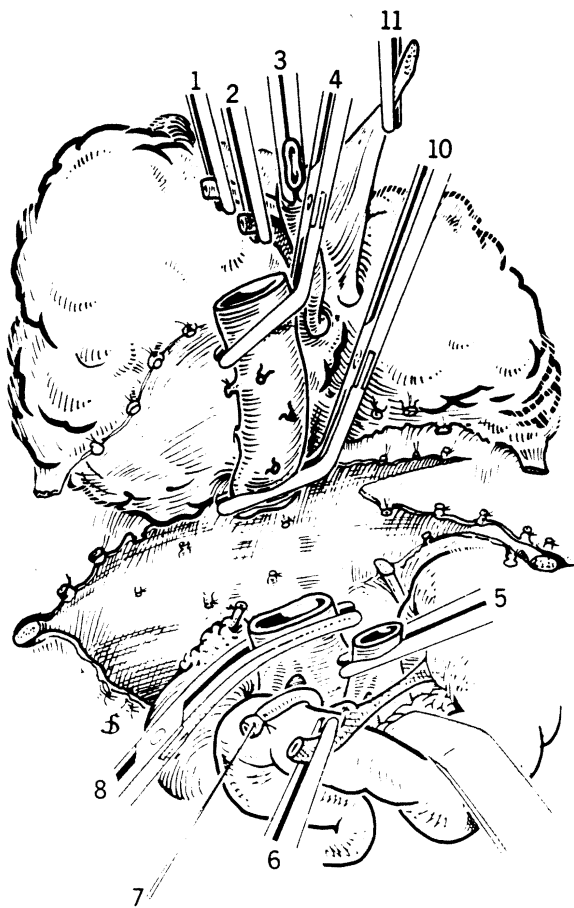


Fig. 121.10 Operative field after retrograde liver mobilization. The last remaining structure; the suprahepatic inferior vena cava, has been clamped above the liver.

Technique for mobilizing a suitable length of suprahepatic vena cava after placement of clamp. In adults, this usually involves cutting away cirrhotic liver tissue over the frequently distorted and foreshortened right and left hepatic veins.

Reproduced with permission from Starzl et al 1976

(Fig. 121.11b). When these continuous suture lines are eventually incorporated into a single suture line, all of the right bare area is eliminated (Fig. 121.11c). The same principle is followed in dealing with the left triangular and falciform ligaments (Fig. 121.11d).

Another line of continuous suture which is of vital importance is that behind the excised recipient inferior vena cava, where the adrenal gland is left behind. This suture line has a superior-inferior orientation and, as it is placed, an effort is made to have at least a double layer by sewing first down and then up (Fig. 121.11e). By the time this final suture line has been completed, virtually all of the bare areas have been eliminated. The time necessary for these haemostatic manoeuvres is 30–60 minutes, an investment which was not feasible before veno-venous bypass was used. If major haemorrhage occurs from the hepatic fossa after the new liver is revascularized, it can be assumed with some degree of assurance that this is from

the graft itself or from one of the anastomoses rather than from raw recipient tissues.

It should be noted that veno-venous bypass has been routinely used only for patients of adult size. Infants and small children tolerate venous occlusion reasonably well and the systematic use of an extracorporeal bypass system would be of doubtful advantage in the majority of cases.

The vascular anastomoses

If adequate cuffs have been developed, the anastomoses of the vena cava above and below the liver are readily performed. During construction of the lower vena caval anastomosis, the liver is flushed with lactated Ringer's solution to remove entrapped air from its major veins and to rid the graft of the high potassium solution used for preservation (Fig. 121.12). Failure to observe these precautions can result in air embolus (Starzl et al 1978) or cardiac arrest from hyperkalaemia.

To reconstruct the portal venous and hepatic arterial circuits, it goes without saying that a flawed anastomosis with subsequent thrombosis usually will either cause death or precipitate the need for retransplantation. To obviate these possibilities, particularly in children who have very small vascular structures, special techniques have been described which in essence are designed to prevent anastomotic strictures (Starzl et al 1984b). The anastomoses of the hepatic artery and portal vein are done in the usual way with a continuous Prolene[®] suture, but a so-called 'growth factor' is left by tying the sutures at considerable distance from the vessel wall (Fig. 121.13). After flow is restored through the hepatic artery or portal vein, the excess of Prolene[®] recedes back into the vessels and redistributes itself throughout the circumference of the suture line (Fig. 121.13). If an additional single suture is placed at the point where the two ends of the continuous suture line meet, thus preventing distraction of the lips (Fig. 121.13), the amount of haemorrhage at the time of flow restoration is surprisingly small. Suture material other than Prolene[®] is not satisfactory for this technique. The Prolene[®] is so slippery that it is not caught by adventitia and can easily work itself back through the entire circumference of the suture line.

Biliary reconstruction

The number of techniques used for restoration of the biliary tract has been large. These are summarized in Figure 121.14. At the present time, the authors recommend only duct-to-duct reconstruction with a stent (Fig. 121.14A,B), or if this is not possible, a choledochojejunostomy to a jejunal Roux limb (Fig. 121.14C). All of the other methods of reconstruction have had too high a rate of morbidity and/or mortality.

Calne (1983) prefers the procedures shown in Fig. 121.14D

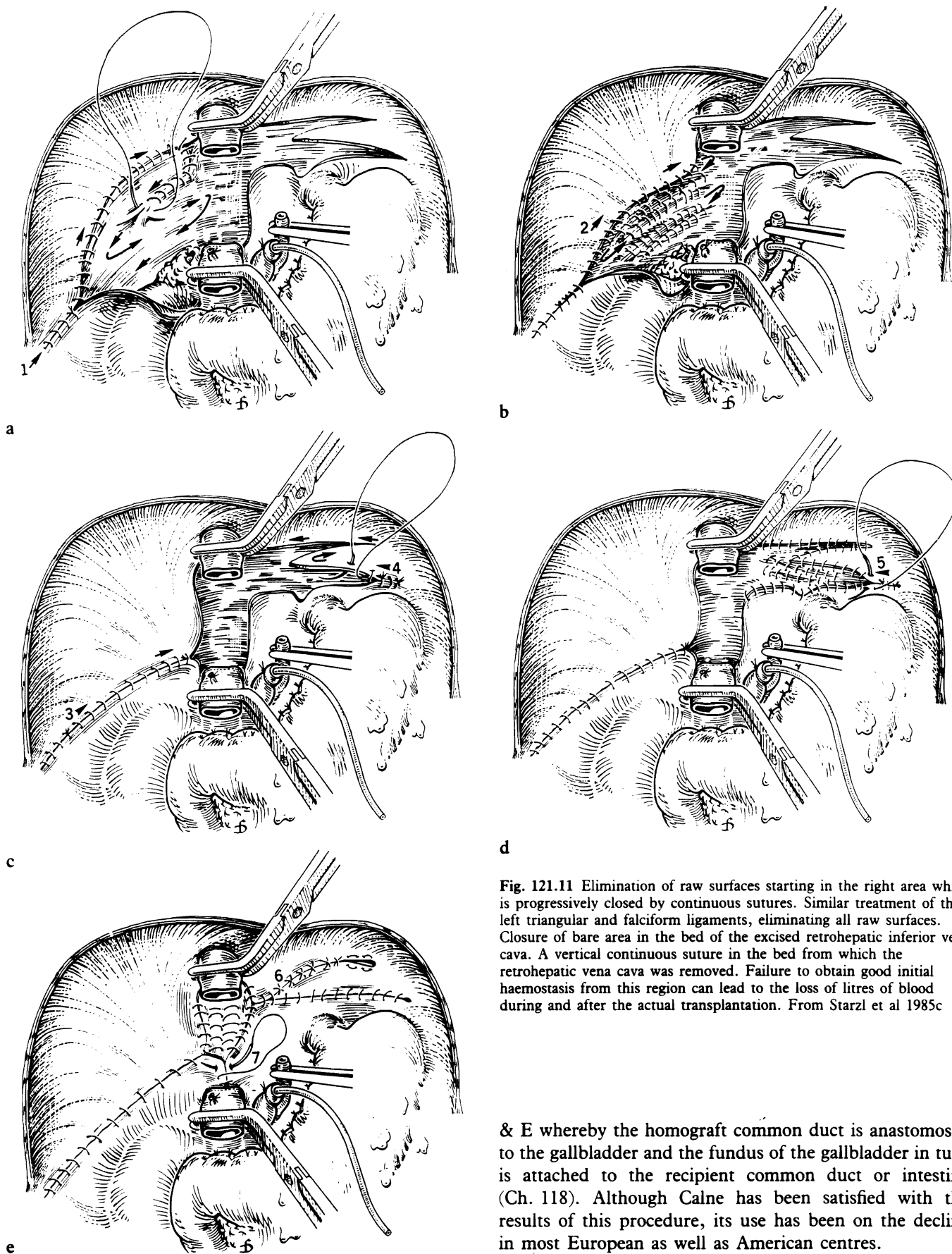


Fig. 121.11 Elimination of raw surfaces starting in the right area which is progressively closed by continuous sutures. Similar treatment of the left triangular and falciform ligaments, eliminating all raw surfaces. Closure of bare area in the bed of the excised retrohepatic inferior vena cava. A vertical continuous suture in the bed from which the retrohepatic vena cava was removed. Failure to obtain good initial haemostasis from this region can lead to the loss of litres of blood during and after the actual transplantation. From Starzl et al 1985c

& E whereby the homograft common duct is anastomosed to the gallbladder and the fundus of the gallbladder in turn is attached to the recipient common duct or intestine (Ch. 118). Although Calne has been satisfied with the results of this procedure, its use has been on the decline in most European as well as American centres.

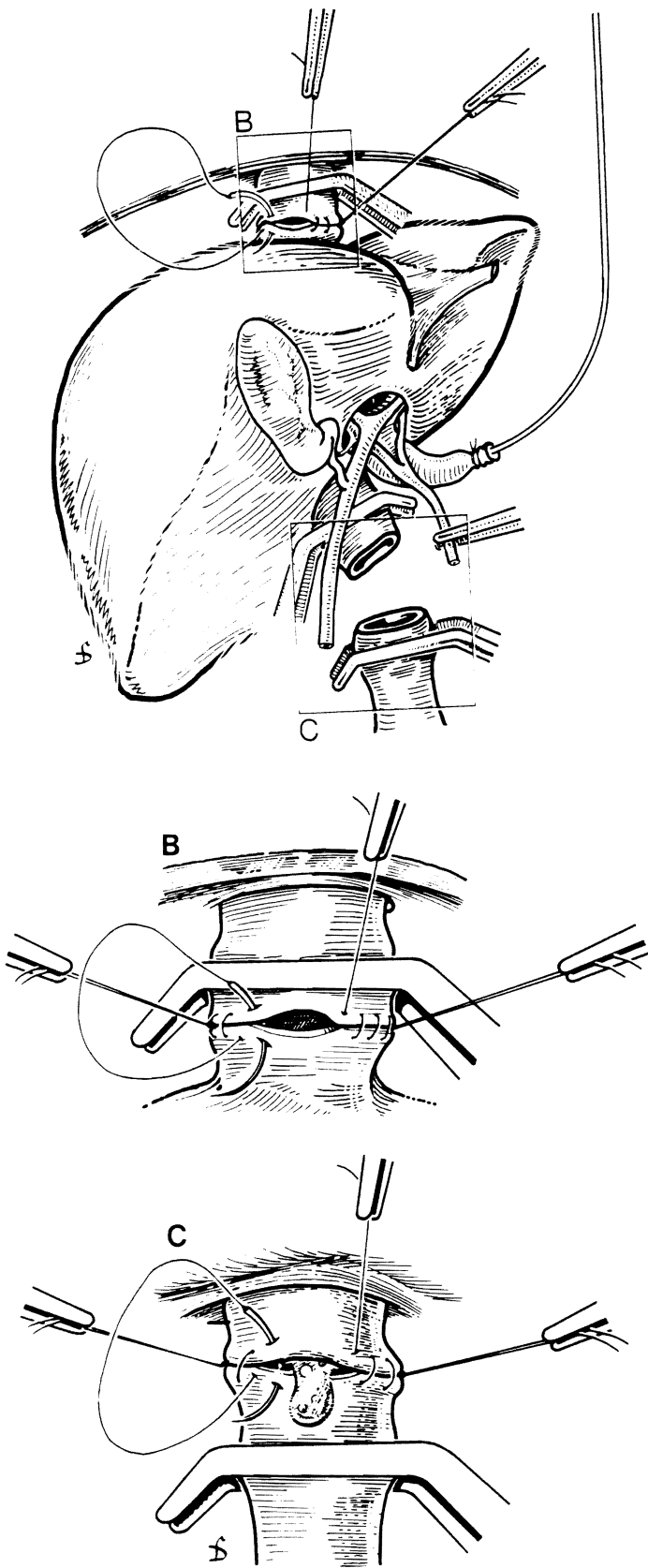


Fig. 121.12 Initial steps in the implantation of a new liver. Infusion with lactated Ringer's solution in order to wash out the potassium rich Collin's solution. (B) Completion of suprahepatic anastomosis. (C) Completion of infrahepatic vena cava anastomosis. Note in (B) and (C) the escape of air bubbles which, if not expelled, could lead to air embolism. Reproduced with permission from Starzl et al 1978

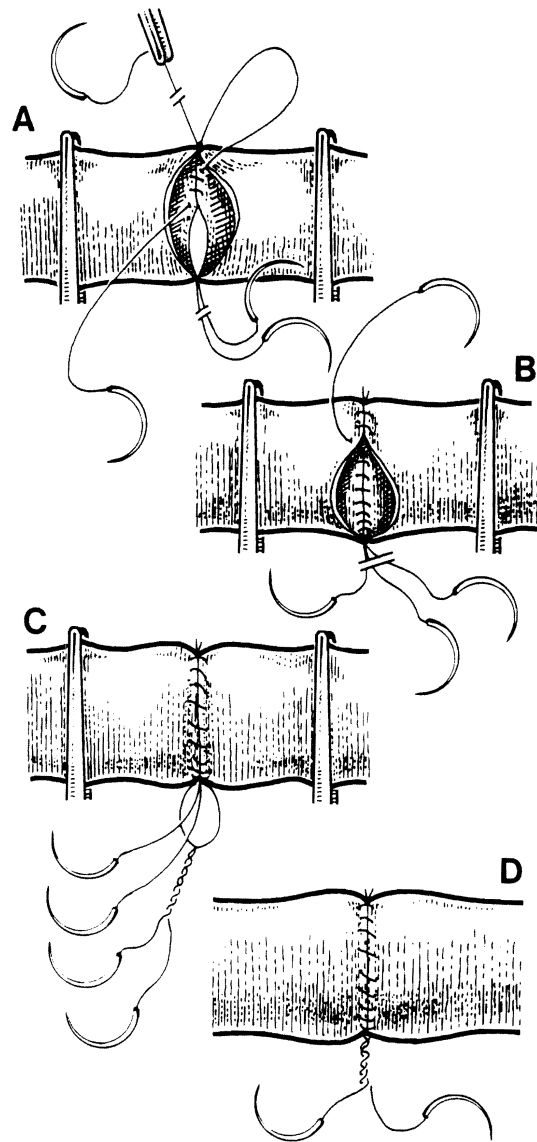


Fig. 121.13 Method of avoiding strictures of small vascular anastomoses. See text for explanation. Reproduced with permission from Starzl et al 1984b

The need for haemostasis

One of the hardest lessons about liver transplantation that had to be learned, and re-learned, has been the necessity for total haemostasis before closing. The assumption that nature will take care of the problem if effective liver function is provided by a homograft has proved to be a vain hope on many occasions. At the other end of the spectrum, even if the patient has received a virtually non-functioning graft, perfect haemostasis usually can be achieved if the surgeon is persistent. Under these circumstances, the anaesthetists have been able to promote clotting with fresh blood products including platelets, and in the event of severe fibrinolysis, by using epsilon aminocaproic acid. The policy has been not to close wet wounds under any circumstances. Many hours of tedious and exhausting work may be required, but such efforts are eventually rewarded by complete haemostasis. After this has been

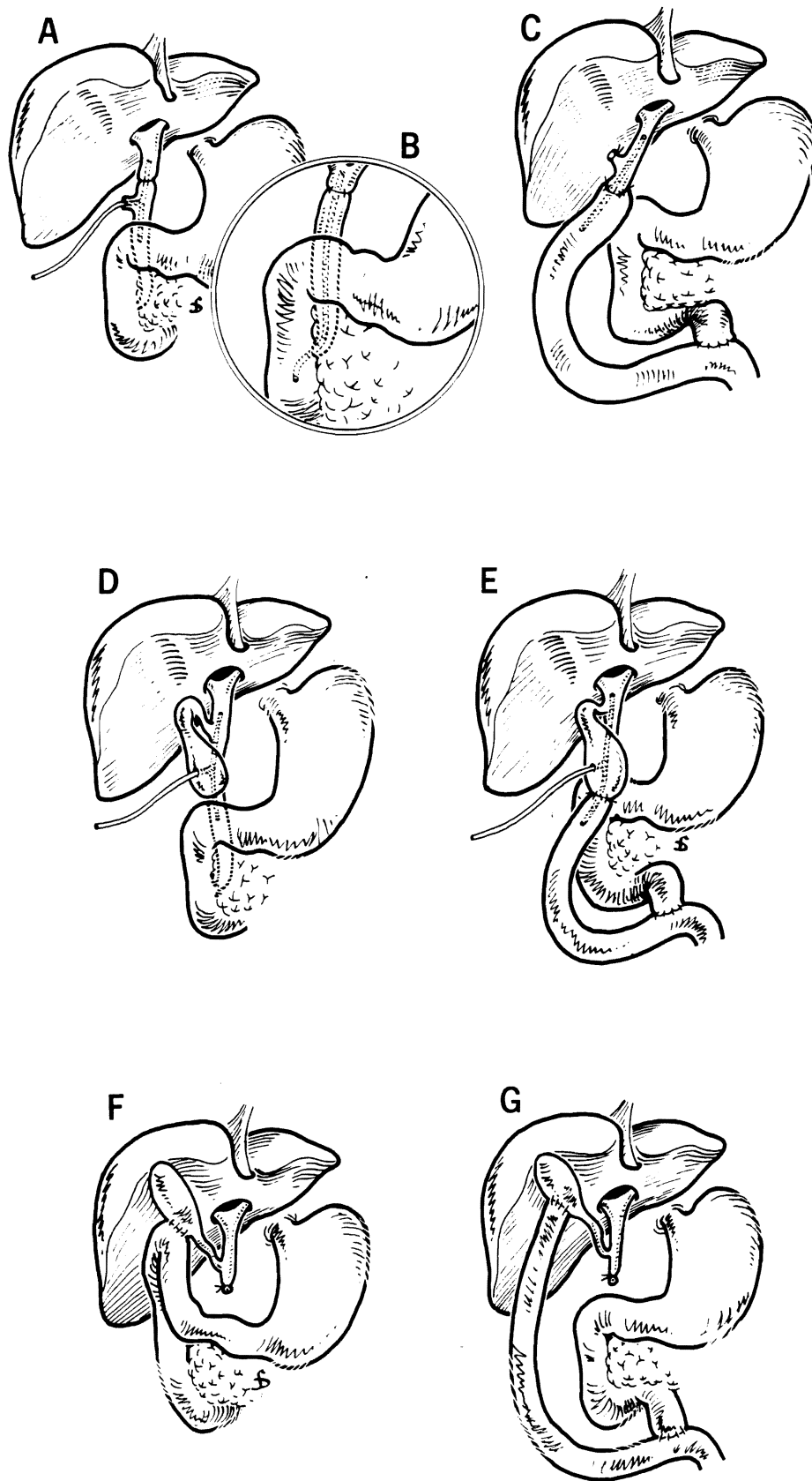


Fig. 121.14 Methods of biliary tract reconstruction that have been used with liver transplantation. The techniques shown in (E and F) are so defective that they have been abandoned. Depending upon the anatomical and clinical circumstances, each of the other methods may be useful in individual cases. Reproduced with permission from Starzl et al 1985a

accomplished, closed sump drains are placed in two or three locations above and below the liver and the wound is closed with non-absorbable sutures.

The struggle for survival continues in the intensive care unit to which the patient is moved. The attending surgeons and physicians have to be consistently aware of a full range of potential complications as described in Ch. 118.

RESULTS

From 1963 through 1979, 170 patients were treated with

conventional immunosuppression. The chances of living for a year after liver transplantation were only about one in three (Fig. 121.15). Subsequently, 244 liver recipients were treated with cyclosporine-steroid therapy between March 1980 and 1 July 1984, allowing follow-ups of one to more than five years. The chances of one-year survival were more than doubled. Actuarial projections beyond one year indicate that these gains will be sustained for at least half a decade (Fig. 121.15).

Influence of age on survival

Justification for stratification into adult and paediatric

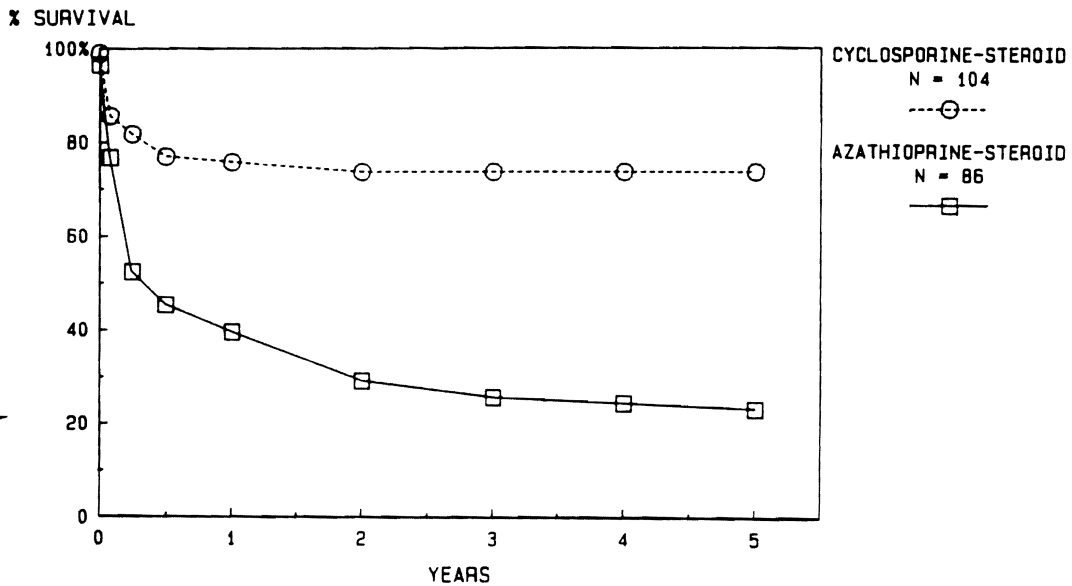


Fig. 121.15 Marked improvement in results of liver transplantation after the introduction of cyclosporine-steroid therapy in early 1980

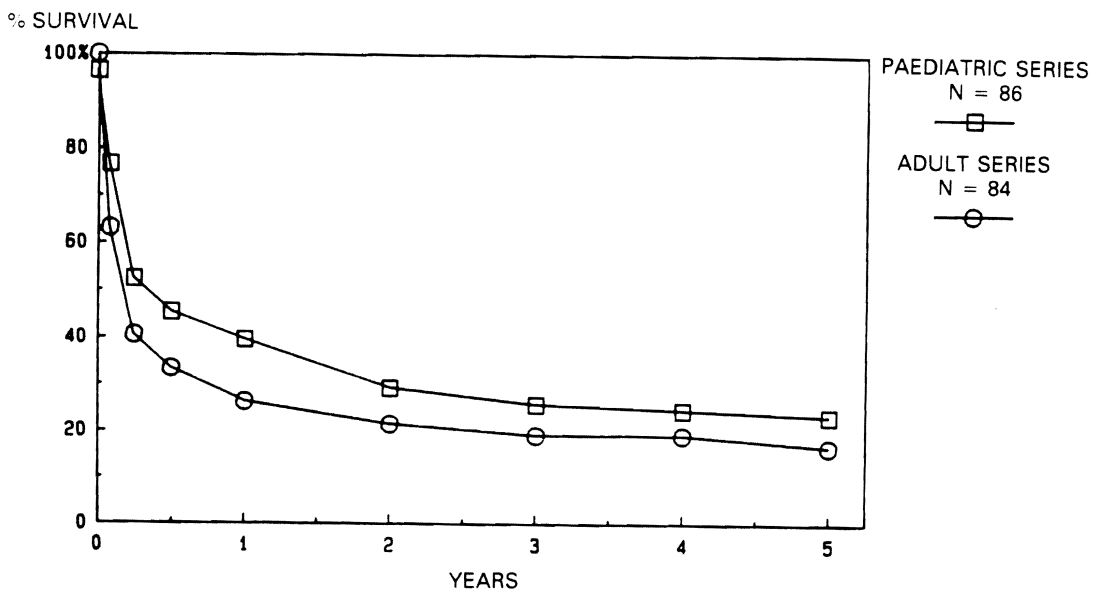


Fig. 121.16 Results with adult versus paediatric liver transplantation under conventional immunosuppression between 1963 and early 1980

categories is the influence of age on survival. It was noted in the days of conventional immunosuppression that the results were better in paediatric recipients (Fig. 121.16). The difference in results in paediatric versus adult cases has been even more striking during the cyclosporine era (Fig. 121.17). The actuarial five-year survival in adults is projected at about 50%, compared to more than 70% for the paediatric recipients (Fig. 121.17).

With the appropriate age stratification, meaningful comparisons become possible between what was achievable in the pre-cyclosporine era versus now. In adults, the projected five-year survival after liver transplantation, while still unsatisfactory, is nearly three times better than

it was previously (Fig. 121.18). In children, the divergence of results using conventional immunosuppression compared to the present time is even more striking (Fig. 121.19).

Influence of diseases upon prognosis

Usually, the nature of the original disease has not profoundly influenced the outcome after transplantation. For example, the results in adults have been similar with such diverse diseases as primary biliary cirrhosis, sclerosing cholangitis and inborn errors of metabolism (Fig. 121.20). Nevertheless, there may be some high risk diseases. So far, the results with post-necrotic cirrhosis and

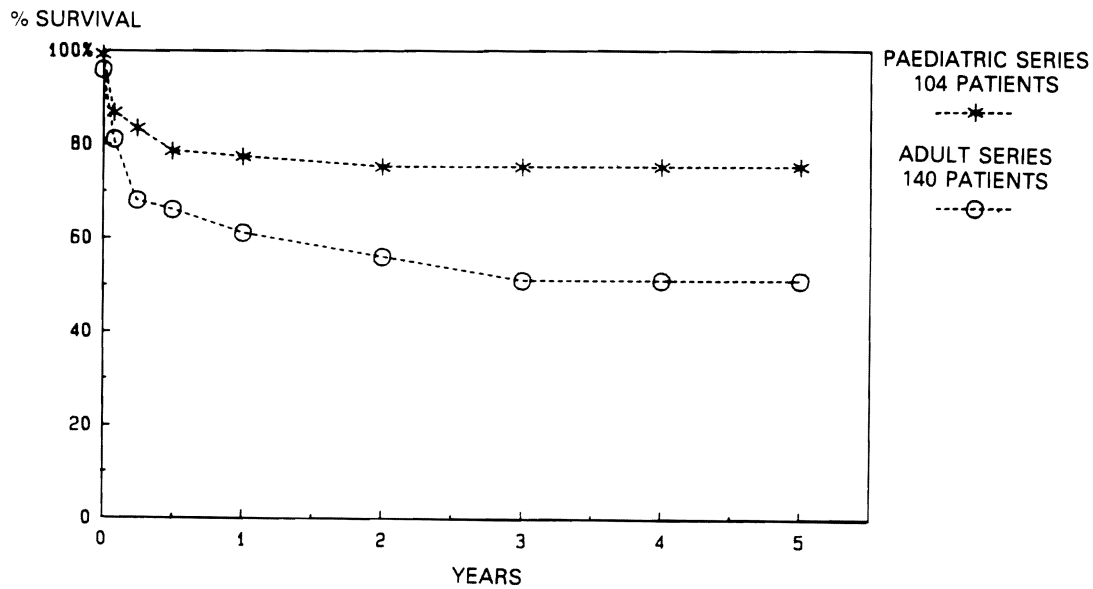


Fig. 121.17 Comparison of results in adult and paediatric recipients during the cyclosporine era of 1980-1984

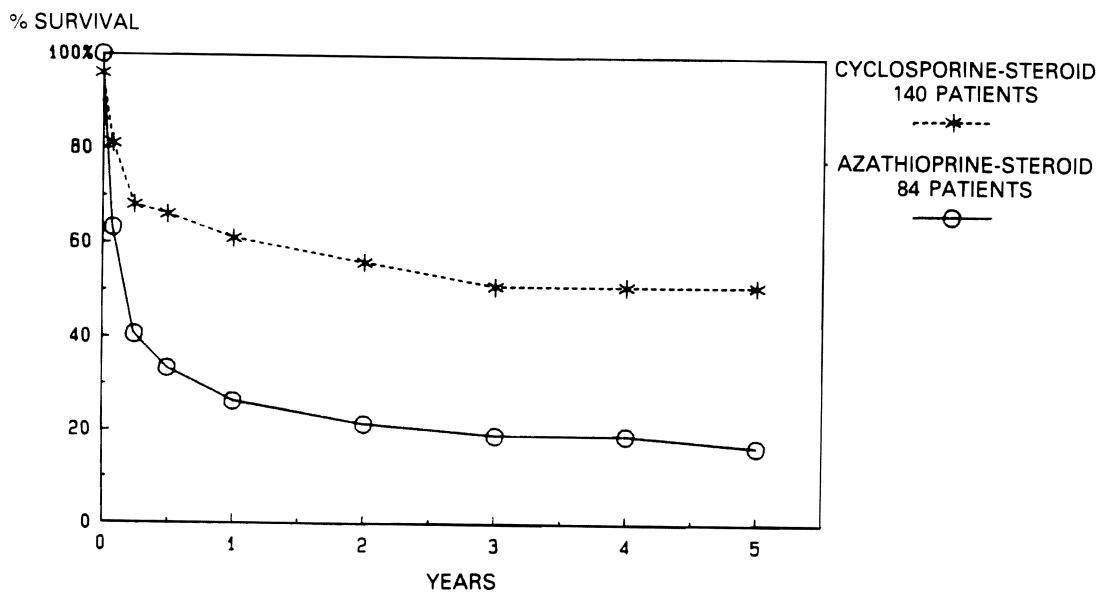


Fig. 121.18 Survival of adult liver recipients in the pre-cyclosporine versus the cyclosporine era

with primary hepatic tumours have been inferior (Fig. 121.21). With cirrhosis, the principal explanations have been the technical difficulties of the operation caused by the disease process, the poor condition of the cirrhotic patients and almost universal recurrence of their original chronic active hepatitis in B-virus carriers.

In patients whose reason for liver replacement was a primary hepatic malignancy, a steady late decline (Fig. 121.21) has been caused by recurrent tumour which has occurred in 80% or more of patients who lived long enough for metastases to be detected. The only acceptable results thus far have been in patients with slow-growing

and non-aggressive fibrolamellar hepatocellular carcinoma which recently has been recognized to be a favourable variant within the larger hepatocellular category.

In children, the results have been about the same in all of the main disease categories (Fig. 121.22). Children with biliary atresia usually have had porto-enterostomies and many have had multiple later surgical interventions in and around the hepatic hilum. Although transplantation is technically much more difficult under such circumstances, there has been no demonstrable penalty in terms either of early or late survival (Fig. 121.22).

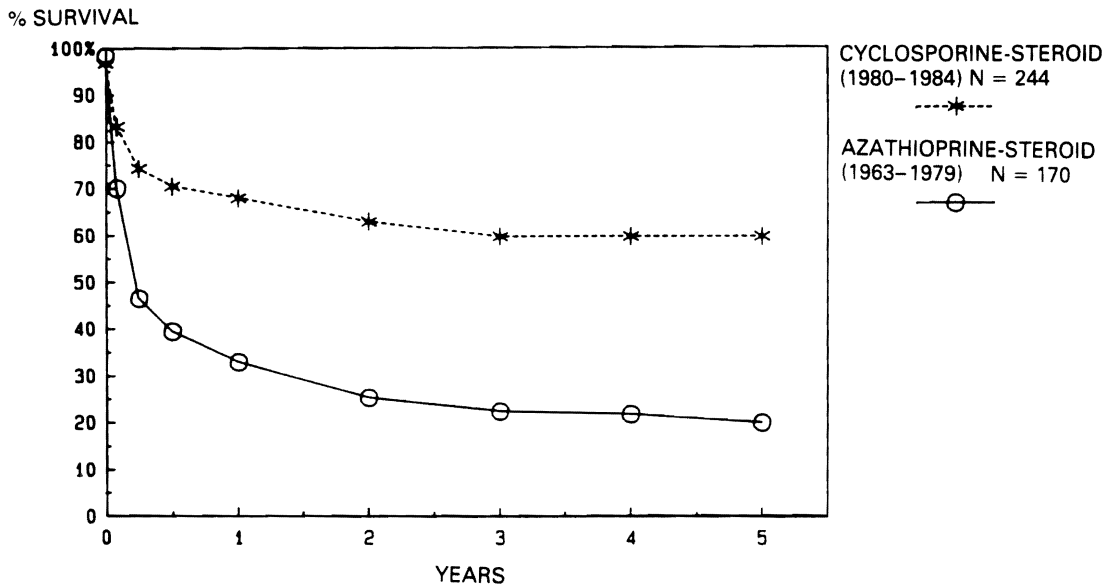


Fig. 121.19 Survival of paediatric patients in the pre-cyclosporine versus the cyclosporine era. Notice the remarkably high survival of children treated with cyclosporine-steroids during the first postoperative year as well as the fact that subsequent losses were extremely uncommon

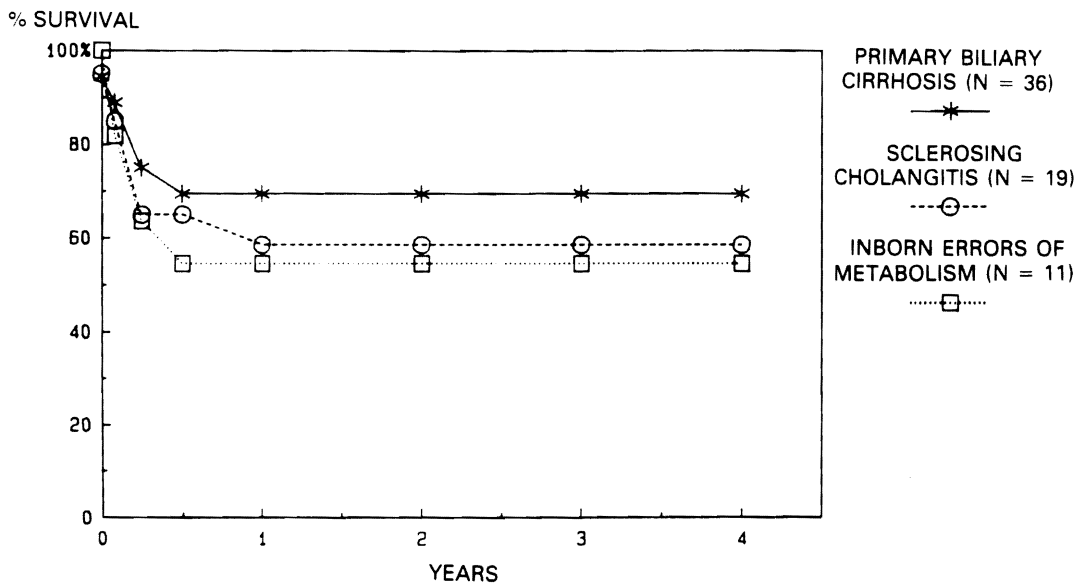


Fig. 121.20 The lack of influence of the underlying disease in adults treated for primary biliary cirrhosis, sclerosing cholangitis, and inborn errors of metabolism

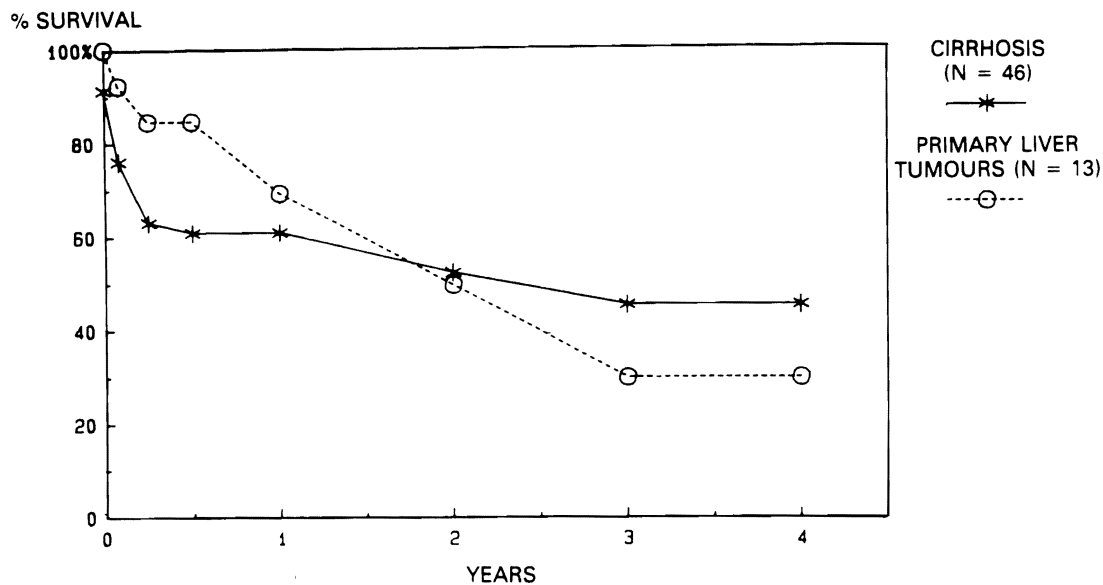


Fig. 121.21 The life survival curves of patients with two 'bad' diseases cirrhosis and primary hepatic malignancy. Note the very high survival of patients with malignant disease during the first half year (85%), but with a steady decline thereafter which was due primarily to the development of metastases

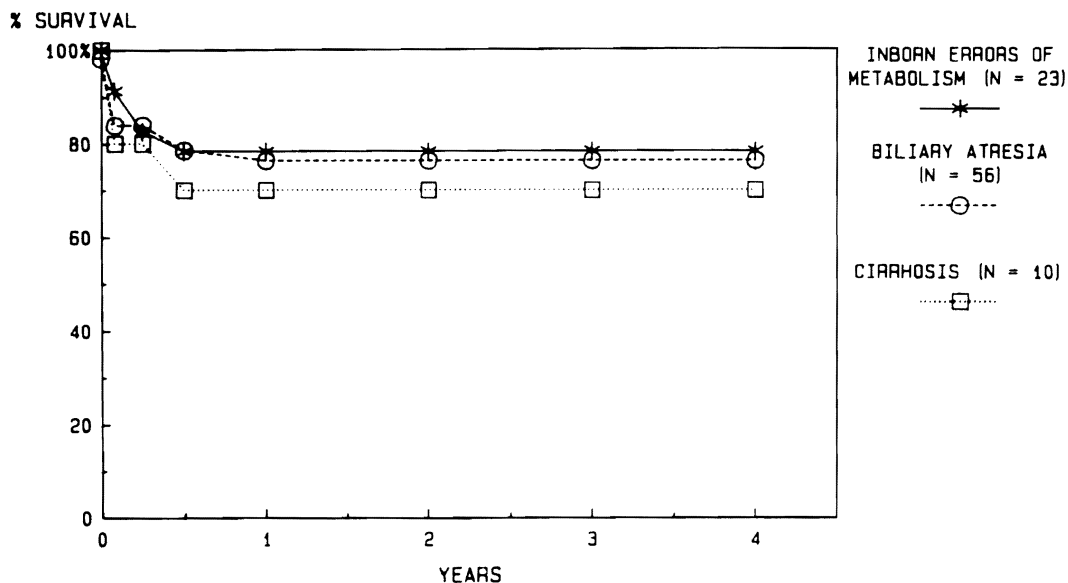


Fig. 121.22 The lack of influence of underlying disease on the survival of children undergoing liver transplantation

REFERENCES

- Calne R Y (ed) 1983 Liver transplantation: The Cambridge-King's College Hospital experience. Grune and Stratton, London
- Calne R Y, Williams R 1979 Liver transplantation. Current Problems in Surgery 16: 3-44
- Denmark S W, Shaw B W Jr, Griffith B P, Starzl T E 1983 Venous-venous bypass without systemic anticoagulation in canine and human liver transplantation. Surgery Forum 34: 380-382
- Gordon R D, Shaw B W Jr, Iwatsuki S, Todo S, Starzl T E 1985 A simplified technique for revascularization of liver homografts with a variant right hepatic artery from the superior mesenteric artery. Surgery, Gynecology and Obstetrics 160: 474-476
- Griffith B P, Shaw S W Jr, Hardesty R L, Iwatsuki S, Bahnson H T, Starzl T E 1985 Veno-venous bypass without systemic anticoagulation for human liver transplantation. Surgery, Gynecology and Obstetrics 160: 270-272
- Iwatsuki S, Shaw B W Jr, Starzl T E 1983 Biliary tract complications in liver transplantation under cyclosporine-steroid therapy. Transplantation Proceedings 15: 1288-1291
- Moore F D, Wheeler H B, Demissianos H V, Smith L L, Balankura O, Abel K, Greenberg J B, Dammin G J 1960 Experimental whole organ transplantation of the liver and of the spleen. Annals of Surgery 152: 374-387
- Shaw B W Jr, Hakala T R, Rosenthal R T, Iwatsuki S, Broznick B, Starzl T E 1982 Combination donor hepatectomy and nephrectomy and early functional results of allografts. Surgery, Gynecology and Obstetrics 155: 321-325

- Shaw B W Jr, Martin D J, Marquez J M, Kang Y B, Bugbee A C, Iwatsuki S, Griffith B P, Hardesty R L, Bahnson H T, Starzl T E 1984 Venous bypass in clinical liver transplantation. *Annals of Surgery* 200(4): 524-534
- Starzl T E (with the assistance of Putnam C W) 1969 Experience in hepatic transplantation. W B Saunders, Philadelphia
- Starzl T E, Kaupp H A, Brock D R, Lazarus R E, Johnson R V 1960 Reconstructive problems in canine liver homotransplantation with special reference to the postoperative role of hepatic venous flow. *Surgery, Gynecology and Obstetrics* III: 733-743
- Starzl T E, Marchioro T L, von Kaulla K, Hermann G, Brittain R S, Waddell W R 1963 Homotransplantation of the liver in humans. *Surgery, Gynecology and Obstetrics* 117: 659-676
- Starzl T E, Bell R H, Beart R W, Putnam C W 1975 Hepatic trisegmentectomy or extended right lobectomy: relation to other liver resections. *Surgery, Gynecology and Obstetrics* 141: 429-437
- Starzl T E, Porter K A, Putnam C W, Schroter G P J, Halgrimson C G, Weil R III, Hoelscher M, Ried H A S 1976 Orthotopic liver transplantation in 93 patients. *Surgery, Gynecology and Obstetrics* 142: 487-505
- Starzl T E, Schneck S A, Mazzoni G, Aldrete J A, Poeter K A, Schroter G P J, Koep L J, Putnam C W 1978 Acute neurological complications after liver transplantation with particular reference to intraoperative cerebral air embolus. *Annals of Surgery* 187: 236-240
- Starzl T E, Hakala T R, Shaw B W Jr, Hardesty R L, Rossenthal T E, Griffith B P, Iwatsuki S, Bahnson H T 1984a A flexible procedure for multiple cadaveric organ procurement. *Surgery, Gynecology and Obstetrics* 158: 223-230
- Starzl T E, Iwatsuki S, Shaw B W Jr 1984b A 'Growth Factor' in fine vascular anastomoses. *Surgery, Gynecology and Obstetrics* 159: 164-165
- Starzl T E, Iwatsuki S, Shaw B W 1985a In: Jr Schwartz S I (ed) *Transplantation of the human liver. Abdominal operations, 8th Edn (Maingot)*. Appleton-Century-Crofts, Connecticut, 1687-1722
- Starzl T E, Iwatsuki S, Shaw B W Jr, Gordon R D 1985b Orthotopic liver transplantation in 1984. *Transplantation Proceedings* 17: 250-258