Multiple Organ Harvesting: Evolution of Surgical Technique—Personal Experience

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SINCE 1950, kidney, liver, heart, and lung transplantations have dramatically improved, emerging as the elective treatment modality for organ failure. Nevertheless, the indications to pancreas and bowel grafting are still controversial.

Several factors have contributed such results, namely the introduction of cyclosporine (CyA) in 1981, the use of new solutions for solid organ preservation (eg, the University of Wisconsin solution), the improvement in donor selection criteria, intensive care, as well as improvement management of transplant operation and harvesting surgical techniques.[1]

The original harvesting operation, especially designed for simple kidney retrieval, has been gradually modified to allow cooperation among different surgical teams and simultaneous retrieval of pancreas,[2] liver, heart, lungs, and bowel from one single cadaver.[3]

The classical "standard procedure" as it was described in the literature[4] consisted of a complete dissection of the visceral vascular structure before its perfusion. The so-called "fast perfusion" technique[5] was initially introduced for hemodynamically unstable donors, then it gained widespread acceptance. The procedure consists of rapid aortic isolation immediately after the abdomen incision, hypothermic crystalloid or colloidal perfusion, with cardiac arrest obtained by cold cardioplegia and followed by total or partial in situ vascular dissection, to be eventually completed on bench surgery. Some other intermediary techniques have also been introduced, consisting of a more or less extensive vascular isolation with a beating or still heart.[6] At the end of the 1980s, the introduction of multiple organ transplantation (liver, pancreas, and bowel), first reported in the United States in 1987[7] and performed at our institution in 1989,[8] prompted a further refinement in harvesting procedures based on the need of reducing the risk of vascular injuries, not unusual in the presence of anatomical anomalies.[9]

The evolution of harvesting techniques at our institution (Table 1), where transplantation activity started in 1966, is the subject of the current paper. In fact, organ retrieval, together with the improvements in preoperative donor care, are the more relevant factors affecting graft function.

Table 1. Harvesting Activity: Personal Experience

	No. Cases
Kidney	476
Liver	134
Pancreas for surgical transplantation	10
Pancreas for islet transplantation	86
En bloc liver, pancreas, and small bowel	5

HARVESTING TECHNIQUE

In the first phase of our experience, abdominal visceral harvesting was performed following the guidelines of the two major techniques described, the standard and the fast perfusion techniques.

The standard technique, particularly advisable in the presence of stable donor conditions, permits an easy identification of underlying anatomic anomalies, whereas the fast perfusion procedure is associated with a remarkable reduction in the duration of the intervention. The latter, advisable in case of sudden hypotension in the course of a standard technique or at the beginning of the procedure, bears a higher risk of vascular injuries, especially in the presence of abnormalities.

The experience achieved over the last decades urged us to improve the aforementioned techniques to reduce the length of the intervention, to avoid vascular injuries (which are far more frequent in the fast perfusion procedure or when hepatic vascular anomalies are present), and to allow multiple organ transplantation as well as combined hepatic and total pancreatic retrieval from one single donor.

The basic steps of our technique include the following:

1. Intestinal derotation followed by aortic and inferior vena cava isolation just above the iliac vessels.
2. Isolation of the inferior mesenteric vein.
3. Systemic heparinization.
4. Aortic cannulation and systemic perfusion with UW solution after clamping of the aorta above the celiac axis. Portal cannulation with a small probe (3 mm) introduced through the inferior mesenteric vein up to the superior aspect of the first portion of duodenum. The venous drainage is performed by means of a large cannula through the inferior vena cava.
5. Splenopancreatic and left colic detachment, followed by retroperitoneal isolation of the aortic portion in-

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cluding the celiac axis and the superior mesenteric artery.
6. Transection of the duodenum at the level of the first portion with mechanical stapler. The stomach is eventually lifted up and the left gastric artery and the gastrocolic and splenogastric ligaments are divided.
7. Total colonic mobilization and transection of its vascular pedicules.
8. Jejunal transection with mechanical stapler at the level of the first loop.
9. Division between ligatures of the superior mesenteric vessels at their preduodenal level.

It is worth noting that in case of combined liver, pancreas, and bowel transplantation, as in four cases of our experience, the superior mesenteric vessels are not divided and the bowel is transected at the level of the distal ileum.

Once these steps have been undertaken, the hepatoduodenal-pancreatic bloc is removed after total transection of the inferior vena cava above the renal veins, excision of an aortic cylinder including the celiac axis and the superior mesenteric artery, and removal of a large diaphragmatic cuff including the suprahepatic portion of the inferior vena cava.

Multiple organ procurement is then completed with removal of both kidneys and the aortocaval axis along the prevertebral plane, according to the well-known guidelines of the standard technique. The harvested organs are preserved for bench surgery to be performed at the donor hospital or at the transplant center.

BENCH SURGERY

This surgical procedure is gaining an ever-growing importance, thanks to the rapid diffusion of transplant surgery, and plays a fundamental role in the organ harvesting technique. Liver bench surgery begins with the isolation of the celiac axis, the splenic and the left gastric artery. The phrenic arteries, when directly emerging from the celiac axis, are divided at their origin. The celiac axis is removed with a small aortic patch.

The proper hepatic artery is not isolated to avoid vascular injuries to the common bile duct, which is eventually transected at the level of the superior aspect of the duodenum. The portal vein is dissected checking for an aberrant right hepatic artery from the superior mesenteric artery. When such an anomaly is observed, we perform an end-to-end anastomosis between a cuff of the superior mesenteric artery, including the right hepatic artery, and the proximal stump of the splenic artery.

In one case in which the pancreas had to be used for transplantation, we have directly anastomosed the aberrant right hepatic artery with the gastroduodenal one. The inferior vena cava is then isolated, the adrenal gland removed, the suprahepatic caval cuff is tailored, and the phrenic veins are suture-ligated.

Colecistectomy is the final step of liver bench surgery.

In case of combined liver and total pancreatic transplantation, we have refined an original anastomotic technique with the interposition of the hypogastric artery between the aorta and splenic artery, without affecting the hepatic vascular supply.[10] When a total bloc including the liver, pancreas, duodenum, and bowel is going to be grafted, bench surgery usually consists of caval isolation and excision of an aortic patch extending from the celiac axis to the superior mesenteric artery.

DISCUSSION AND CONCLUSIONS

Undoubtedly, the current shortage of organs for transplantation can be solved with the adoption of different solutions, for example, improving preoperative donor care and using marginal donors.[11] Furthermore, refining harvesting techniques is also necessary to avoid tissue and vascular injuries, often frequent in case of anatomic anomalies, as is standardizing a feasible procedure that is easily reproducible by a single team for multiple visceral retrieval.

The standard technique, even if allowing an easy identification of vascular anomalies, is more time consuming than the fast perfusion technique and may cause severe tissue damage, secondary to arterial spasm or perfusion alteration. On the other hand, the fast perfusion technique allows rapid and ideal organ perfusion, but requires dissection of bloodless vascular structures, which may be difficult in cadavers, often causing severe vascular injuries.

Some groups have successfully adopted another technical option consisting of a simple aortic perfusion, while the portal vein is perfused on bench surgery, immediately after liver removal.[12]

The technique reported here has the advantage of reducing vascular dissection only to the aortocaval axis, whereas different organs are prepared on bench surgery. Such a technical option, which we have adopted in the last 75 multiorgan retrievals, has been associated with an acute tubular necrosis rate of less than 10% and a delayed liver function rate smaller than 16%.[13] It is remarkably easy and safe, reproducible, and feasible.

A statistical analysis of all liver harvesting procedures using UW solution has been done to assess the relationship between the incidence of delayed liver function and some parameter,[14] such as donor age, incidence of severe hypotensive episodes, hypothermia, clotting impairment (quick time lower than 30%), use of vasopressive agents, intensive care unit (ICU) stay, sodium levels, MEGX test, and cold ischemia time.[15–17] Such a survey has shown statistical significance only for cold ischemia time ($P < .001$; Fig 1).

On the basis of our experience and in agreement with other authors, excessive organ manipulation and a long duration of the harvesting procedure,[18] especially if performed by inexperienced teams, are the main factors affecting the graft recovery after reperfusion. Prolonged cold ischemia time under UW regimen may be the cause of the high incidence of delayed but not primary nonfunction of the liver.[19,20]

Our results clearly show that abdominal organ retrieval,

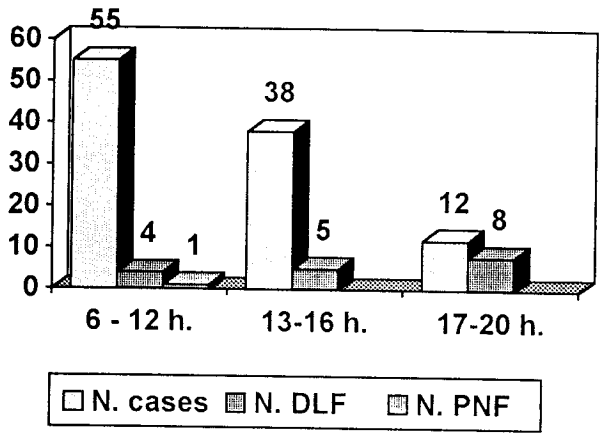

Fig 1.

namely liver harvesting, should be performed in a fast, standardized, and easily reproducible way. Moreover, liver procurement should no longer constitute a limitation for whole pancreas removal. The success of pancreas or islet transplantation is strictly related to the relative warm ischemia time which is frequently prolonged using the fast perfusion technique with sequential liver and pancreas retrieval; therefore, the en bloc technique should be preferred in these cases.

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