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Organ procurement in children – surgical, anaesthetic and logistic aspects

J.B. Otte[1], J.P. Squifflet[2], M.C. Carlier[3], B. de Hemptinne[1], P. Gianello[2], Th. Dereme[2] and G.P.J. Alexandre[2]

Department of [1]Pediatric Surgery, [2]Renal Transplantation and [3]Anesthesiology, University of Louvain Medical School, Hôpital St.-Luc, Brussels, Belgium

Abstract. To cover the need in paediatric organ transplantation, every potential donor should be considered as a multi-organ donor. Successful transplantation may be performed with kidneys retrieved from very young infants, even anencephalic neonates if the en-bloc technique using both kidneys is used. Regarding the liver, paediatric donors can be accepted from one month of age while livers harvested from older children and even young adults can be transplanted into small children after ex-vivo reduction of the size of the graft. Multi-organ procurement from the same donor provides valuable organs if the anaesthetic management of the donor is appropriate. Active transplant programs needs international cooperation which is made possible by the organ exchange organizations.

Key words: Organ transplantation – Organ procurement in children

Because of advances in transplantation of solid organs, more and more children with end-stage organ failure are receiving transplants. This development has increased the need for paediatric donors although the problem has slightly different aspects for the various organs which are currently transplanted.

Renal transplantation has not been hampered by the shortage of paediatric donors since paediatric recipients, even small children, can be transplanted with adult kidneys. It follows that paediatric kidneys so far have not been reserved for paediatric recipients. Since almost 25 years, most brain-death donors used in cadaver renal transplantation were between 2 and 50 years old. If the upper limit has been extended over 55 years, and more recently over 65 years, the same trend has not been followed for the lower age limit.

Many transplant surgeons have been reluctant to use paediatric kidneys for adult recipients because of a higher incidence of hypertension and a greater tendency to destruction during acute rejection episodes. However this has not been our experience. In an analysis of 419 primary cadaver transplants performed at our centre and treated with conventional therapy, no difference was seen in respect to the graft functional survival rate between the group of adults receiving a kidney from a donor less than 15 years old and another group whose donors were 15 or more years old (74% and 77% respectively at one year). The mean blood pressure was identical at one year in both groups although the recipients of the first group were taking significantly more hypotensive drugs than in the second group [1].

Only experienced centres accept kidneys retrieved from donors less than 2 years old. These kidneys can be implanted into paediatric or adult recipients with an en-bloc technique including the aorta and the vena cava. This technique has been used successfully more than 10 times in our institution. Moreover, Kinnaert et al. [2] reported that 9 pairs of kidneys harvested from anencephalic donors were transplanted within the Eurotransplant organization with a 66% success rate; one of these pairs was transplanted in our centre.

The number of patients waiting for a kidney graft is ever increasing in all european countries; only inside Eurotransplant more than 7000 are waiting and 251 of them died on dialysis in 1986 [3]. Due to that crucial need of organs and the lack of suitable donors, we recommend that every paediatric donor be taken into consideration whatever its age. For donors less than 2 years old, the en-bloc technique should be used to transplant both kidneys with the aorta and inferior vena cava in the recipient (child or adult). For donors older than 2 years, each kidney should be grafted separately, reserving kidneys harvested from young paediatric donors (2 to 10 years) for transplantation in paediatric recipients.

Liver transplantation does not enjoy the same flexibility regarding the size of the graft as renal transplantation. Indeed the grafted liver has to be placed in orthotopic position; it should therefore match closely the size of the diseased liver. It follows from this that, in paediatric liver transplantation, donor and recipient should be closely matched regarding age and weight. Paediatric livers should therefore be reserved by priority for transplantation into paediatric recipients in as much as a large proportion of the paediatric candidates for liver replacement are very young (under 3 years) and very small (below 15 to 20 kg). In our experience, small children evaluated for liver transplantation represent two-thirds of the total paediatric population. The dramatic shortage of small paediatric liver donors can be alleviated, at least partly, by the volume reduction of the liver harvested from older and bigger donors [4].

Regarding the lower age limit of the potential liver donor, use of neonatal livers is probably unsafe due to the functional immaturity and the increased risk of hepatic artery thrombosis [5]. Currently we are willing to accept livers from paediatric donors older than one month.

Clinical experience with heart transplantation in children is still very limited; indications are ill-defined and long-term results are lacking. There is little doubt however that expansion of this field will occur in the near future, with a need even greater than in liver transplantation for a graft that is well matched regarding its size with the diseased organ.

Clinical experience with pancreas transplantation is still limited. Most of the recipients are young adults who benefit by transplantation of pancreas harvested from adult donors in order to increase the islet mass engrafted [6]. Moreover due to the scarcity of small paediatric donors, an absolute priority should be given to liver procurement even if combined harvest of liver and pancreas can be performed with successful transplantation. Nevertheless sharing of the vascular pedicles between the two grafts can be a source of technical problems and even a technical impossibility in case of arterial anomalies. In the future, paediatric pancreas most probably will be used for free islet grafting and even for whole organ transplantation into paediatric recipients if the liver cannot be harvested for any reason.

Small intestine transplantation is at best at the eve of clinical application. It can be foreseen that most of the recipients will be children but, as in pancreas transplantation, more flexibility will be present regarding organ procurement since the use of older donors could be the best option.

Our comments regarding the surgical aspects, the anaesthesia and the logistics of organ procurement in children will be confined mainly to the liver and the kidney.

Surgical aspects

The criteria used in the selection of a potential donor are analysed elsewhere in this issue; some of them are common to the different organs, some are specific to a given organ. It has been our experience as well as that of other groups that the practice of the harvesting surgeon is of the greatest importance.

In order to cover the need in various organs transplantation, every donor should be considered as a multi-organ donor. Until recently, many kidney transplant teams were concerned by the potential interference of liver and heart harvesting with the anatomical and functional integrity of the simultaneously retrieved kidneys so that they were reluctant to report a possible organ donor for procurement of other organs. The experience of many groups including ours has proved that this fear was not justified if appropriate techniques and coordination between the different teams involved in harvesting were used (see infra). Every one of the donors of our first 58 paediatric liver transplants has been submitted to a multiple-organ harvesting; liver and kidneys were procured from 40 donors, liver, kidneys and pancreas from one and liver, kidneys and heart or heart-lungs from the remaining 17. The techniques of multiple-organ harvesting from the same donor is nowadays well standardized and has proven to be fully reliable in experienced hands [7–9]. The early function of the renal grafts is not endangered if anesthetic management of the donor is appropriate [10].

Harmonious integration of different harvesting teams is possible although is has been our experience that the best approach was to have one single team mastering the harvesting of all abdominal organs.

Anesthetic management

The role of the anesthetist in cadaver organ procurement is to maintain good haemodynamic conditions with maximal fluid and blood administration. That role must be considered in 3 phases. Firstly, all donors are monitored with electrocardiogram, SBP and CVP lines and urinary catheter, as are living-related donors [11]. Secondly, they are managed with colloid and/or crystalloid solutions, in order to maintain an adequate SBP and a satisfactory urine output. Davidson et al. have clearly shown that both types of solutions are equally elective; the proportion of each component depends upon the centre policy [11]. Blood loss must be compensated to maintain the haematocrit higher

than 30%; the aversion of blood administration must be weighed against the fact that blood transfusion in the donor been has reported to prolong graft survival in the cadaver kidney recipient [12, 13]. Finally, all donors may receive selected drugs. Dramatic haemodynamic responses were reported by Wetzel et al. [14] in brain-dead patients undergoing surgery – these responses did not, however, invalidate the current criteria for the diagnosis of brain death – it is important to use agents such as muscle relaxants (pancoronium) and fentanyl prior to start surgery in order to avoid any haemodynamic modifications. More controversies are reported about the use of heparin which seems to have a deleterious effect when added to the preservation fluid for kidney storage [15–17]. However, its parenteral use has worldwide acceptance, as has dopamine at slow rates which improves the perfusion of the organs [18].

If the beneficial effect of phenoxybenzamine is clear in kidney harvesting [15], its use in multiple organ donor (MOD) must be restricted until valid experimental data proving its safety in heart, liver and pancreas graft are obtained. Again, the positive influence of intravenous administration of mannitol is obvious in kidneys donors, but it must be also avoided in preservation fluids [19–21]. In conclusion, these general rules can help the anesthetist in managing MOD. In our experience [22], they permit satisfactory retrieval of 34 kidneys, 6 pancreas, 12 livers and 3 hearts from 18 multi-organ donors.

Logistics

Organ exchange organizations have gained great experience in sharing organs between the transplant centres. They have contributed to a large degree to the progress achieved in organ transplantation. Criteria for selection of the multi-organ donors and urgency codes have been defined and interconnection has developed between the national and supranational organ procurement agencies.

The organization of a multi-organ harvesting requires a great deal of coordination which is best secured by transplant coordinators working on an institutional or a regional basis. In several european countries positions have been created on a national level; this approach increased the efficiency of organ sharing and should be encouraged. The practical steps to be taken for a given multi-organ procurement should consider the specific requirements regarding histocompatibility, cross-match and preservation techniques. Kidneys can be preserved for a long period of time, up to 48 h; this allows postponement of the identification of the best matched recipients and the shipment of kidneys after the retrieval.

Preservation of liver and heart is more time limited, not in excess of 8 to 10 h for the liver and 3 to 4 h for the heart. Presently histocompatibility is neglected for both organs and preformed cytotoxic antibodies do not preclude a successful liver transplantation. Practically speaking, organization of a given multi-organ procurement regarding timing and coordination between harvesting teams should be centered around the liver and the heart teams. Whenever the donor haemodynamic condition is stable, they should be given the priority for timing the harvesting.

Active organ transplant programs require organ sharing within large population areas. With appropriate logistics and means of transport, this sharing can be extended beyond the national boundaries to cover most of the european countries from any given point. This strategy is well illustrated by our own experience in pediatric liver transplantation. Among the first 59 pediatric livers transplanted in our institution, five were harvested locally, ten were procured from other belgian hospitals and 44 from hospitals located in other countries. Ischaemia time was kept within safe limits, being of 3 h 53 min (±1 h 30), 4 h 55 min (±0 h 53) and 6 h 13 min (±1 h 11) respectively. Transportation was choosen to cover the distance from the harvesting center to our hospital in less than 2 h allowing to keep the total ischaemia time (including the completion of harvest, the return journey, the preparation of the retrieved liver on a back table and the implantation of the graft into the recipient) under 6 to 8 h. Among 54 liver procurements outside our hospital, ground transport was elected on 14 occasions (mean ischaemia time: 5 h 20 min ±1 h 23) and air flight transport on 40 occasions (mean ischaemia time: 6 h 11 min ±1 h 08) for a distance below 500 km in 24 cases (mean ischaemia time: 6 h 09 ±1 h 23), between 500 and 750 km in 9 cases (mean ischaemia time: 6 h 20± 0 h 43) and above 750 km in 7 cases (mean ischaemia time: 5 h 51±1 h 20).

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Dr. J.B. Otte
Department of Pediatric Surgery
Hôpital Saint-Luc
Avenue Hippocrate 10
B-1200 Brussels
Belgium