“Super-rapid” Technique in Donation After Circulatory Death Liver Donors: Advantages and Disadvantages

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ABSTRACT

In recent years, donation after circulatory death (DCD) has increased as an option to overcome the organ donor shortage crisis and to decrease the large number of patients on liver transplant waiting lists. The “super-rapid” technique is now the “gold standard” procurement method because of its availability, reproducibility, low cost, and extensive experience. Recently, extracorporeal support has been implemented, with encouraging results. Strict donor acceptance criteria have proven to be essential to optimize the DCD liver graft outcomes and minimize biliary complication rates. In this study we assessed the state of the art of DCD liver transplantation with regard to its development and the actual strategies to prevent graft complications, with aim of expanding the pool of marginal liver donors.

THE SUCCESS of solid-organ transplantation has increased the number of recipients, but this has led to insufficient donation rates and considerable waiting list mortality in recent years. The current strategy to enhance the donor pool now includes donation after circulatory death (DCD).

According to the Maastricht model, controlled DCD involves planned withdrawal of ventilatory and organ perfusion support (Maastricht III with or without IV), whereas uncontrolled DCD involves unexpected cardiopulmonary arrest and/or unsuccessful resuscitation (Maastricht I and II, with/without IV). Type III comprises a larger, more effective number of donors [1].

Spain has the third highest level of DCD activity, just behind the USA and the UK. In Spain, the use of DCD donors for liver transplantation has been gaining in popularity, with increasing rates of acceptance (from 11% to 68%) in the last 8 years [2].

“SUPER-RAPID” PROCUREMENT TECHNIQUE

The first and most common method for recovery of organs is known as the “super-rapid” technique. It is a well-described approach and has proven to be effective by established organizations [3–8], such as the American Society of Transplant Surgeons (ASTS) [9]. Following the approach utilized by the University of Pittsburgh team [3], this technique starts with a midline laparotomy to access to the distal aorta, which is cannulated to start the perfusion of organs with cold preservation solution. It should be initiated in less than 4 minutes after skin incision to reduce the warm ischemia time. Next, the supraceliac aorta is cross-clamped, and the intrapericardial inferior vena cava is vented to avoid organ engorgement. The inferior mesenteric vein is then cannulated to perfuse the portal system. Once the liver becomes cold and free of blood, en bloc hepatectomy is performed expeditiously.

It is strongly recommended that this technique be performed by experienced donor surgeons, because better short- and long-term outcomes have been shown with minimized warm and cold ischemia times and fewer lesions during the hectic recovery procedure [9–11].

DCD Liver Graft Experience

Initial experiences were reported by the Pittsburgh [3,4] and Wisconsin [5,6] teams. The former, after a comparison between nonselected DCD and donation after brain death (DBD) in well-matched cohorts, showed that DCD patients had significantly lower graft survival and up to 67% of

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patients had early graft failure, with primary nonfunction (PNF) (12%) and biliary complications (25%) as the main causes. Furthermore, a higher retransplantation rate (18% vs 7%) was observed in DCD liver recipients. Once the risk factors were identified (warm ischemia time [WIT] >30 minutes, older donors, cold ischemia time [CIT] >12 hours), these groups established a donor age limitation <60 years and WIT <30 minutes for minimizing graft complications.

To achieve better DCD liver grafts outcome rates, a group from The Netherlands [7] established strict acceptance criteria for controlled DCD, including Maastricht category type III, WIT <30 minutes, age <55 years old, body mass index (BMI) <28, and hypotensive period (systolic pressure <50 mm Hg) <15 minutes. They described similar rates of patient and graft survival, primary nonfunction, and hepatic artery thrombosis as for DBD liver transplantation. However, a higher risk of biliary events persisted in DCD grafts.

The more frequent biliary complications are ischemic-type biliary lesions (ITBLs), defined as diffuse nonanastomotic biliary strictures, with or without prestenotic dilation, in the presence of a patent hepatic artery [10].

These are the primary causes of worse outcomes after DCD liver transplantation, with a 10.8-fold increased odds of ITBL reported (16% of DCD vs 3% of DBD recipients) in a recent meta-analysis [12]. Although several risk factors have been described (older donor age, WIT <35–40 minutes, and CIT >8–10 hours), they have not been reported unanimously in all studies [7–10,13].

Recently, the King's College group [8] performed an analysis focused on biliary complications from DCD liver grafts, but they did not observe higher rates compared with DBD donors, nor independent risk factors to avoid them. They highlighted the importance of a standardized protocol for the DCD procedure, as mentioned earlier, and use of strict donor acceptance criteria has certainly proven essential in minimizing biliary complications.

CURRENT IMPROVEMENT STRATEGIES

The British Transplantation Society (BTS) guidelines [13] describe a lower ITBL incidence when using a low-viscosity solution (eg, HTK solution) to cold flush the aorta, as well as when using a pressurized aortic and backtable flush for more effective perfusion of microcirculation of the bile ducts. However, this has not been well proven in other studies of DCD transplantation [10].

The use of fibrinolytic drugs, such as tissue plasminogen activator, has also been described to avoid thrombus formation in peribiliary arteries, but no clear benefit has been reported, considering that the arterial thrombi theory as a cause of ITBL is not supported by current evidence. Other techniques, such normothermic abdominal regional perfusion (NRP) and hypothermic machine perfusion (although experience is limited), seem to improve the quality of marginal grafts and rate of ITBL [10].

NRP represents a potential method to increase the pool of donors and minimize ischemic injury to Maastricht III DCD grafts. The approach restores circulation with oxygenated blood to the abdominal organs in situ using extracorporeal membrane oxygenation (ECMO) at body temperature, which implies turning a warm ischemia period into an ischemic preconditioning period. This allows for standard elective procurement without haste, which is likely to reduce organ injury and discard rates compared with the "super-rapid" technique [14].

According to the last DCD activity report in Spain [2], a trend toward higher graft survival has been observed with NRP vs the "super-rapid" technique, with lower rates of PNF and ITRL of liver grafts. These results did not achieve statistical significance and they did not include a subgroup analysis and the presence of a learning curve for the "super-rapid" technique in many national groups.

In Spain, 1- and 2-year uncensored patient and hepatic graft survival rates from DCDs (Maastricht III) were no different from DBDs [2].

Nonetheless, a report from Michigan [15] described up to 21.6% of problems being related to extracorporeal support, among them low vessel flow, severe bleeding, cannulation problems, and aortic balloon migration, leading to graft loss (38.1%) or immediate conversion to the "super-rapid" technique (19%). Thus, caution is advised.

A higher BMI has been identified as a risk factor for graft injury due to the haste in removing organs to minimize the WIT (particularly liver capsular damage, up to 15.6%) during the "super-rapid" technique, but no major change in rate of vascular lesions was observed [11]. These risk factors are minimized when procurements are done at high-volume centers by experienced donor surgeons.

Hence, following the BTS guidelines, an ideal DCD liver graft would imply a donor <50 years old, a functional WIT time of <20 minutes, a CIT of <10 hours, steatosis <10%, and a BMI of <29 kg/m^2 [13].

CONCLUSION

Improving DCD outcomes will have a major positive impact on the donor liver shortage. The "super-rapid" approach is the procurement technique of choice at most centers. Strict donor acceptance criteria are essential to improve graft and patient outcomes. Further studies are required to fully assess the impact on organ recovery rates and lowering posttransplant complications when comparing the "super-rapid" technique and extracorporeal support.

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