Intraoperative Pleth Variability Index Is Linked to Delayed Graft Function After Kidney Transplantation

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ABSTRACT

Background. Delayed graft function (DGF) is an early postoperative complication of kidney transplantation (KT) predisposing to acute rejection and lower graft survival. Intraoperative arterial hypotension and hypovolemia are associated with DGF. Central venous pressure (CVP) is used to estimate volemia but its reliability has been criticized. Pleth variability index (PVI) is a hemodynamic parameter predicting fluid responsiveness. The aim of this study was to examine the relationship between intraoperative PVI and CVP values and the occurrence of DGF.

Methods. This was a prospective, noninterventional, observational, single-center study. All consecutive patients with KT from deceased donors were included. Recipients received standard, CVP, and PVI monitoring. Intraoperative hemodynamic parameters were recorded from recipients at 5 time points during KT.

Results. Forty patients were enrolled. There was a poor correlation between PVI and CVP values ($r^2 = 0.003$; $P = .44$). Immediate graft function and DGF patients had similar hemodynamic values during KT, with the exception of PVI values, which were significantly higher in the DGF group. In particular, a PVI >9% before unclamping of the renal artery was the only predictive parameter of DGF in our multivariate analysis ($P = .02$).

Conclusions. This study suggests that PVI values >9% during KT are associated with the occurrence of DGF.

DELAYED graft function (DGF) due to ischemia-reperfusion injury is a major early complication of kidney transplantation (KT) [1]. DGF is usually defined as the requirement for dialysis in the 1st week after KT [1] or as the absence of the usual rapid drop in serum creatinine level (eg, 10% at day 2) [2]. DGF is thought to be one of the most important independent variables of chronic allograft failure impairing both graft and patient survival [1,3].

The incidence of DGF is usually estimated to be between 30% and 50% but may be increasing owing to the more widespread use of expanded donor criteria [4]. DGF can be considered as the result of an accumulation of various deleterious factors for the kidney graft. Donor-related characteristics, such as age, tissue quality, and cause of death, play a key role in graft function. Factors related to procurement, cold storage, and reperfusion injury are crucial for the early performance of the graft and affect its long-term functioning [5]. Intraoperative arterial hypotension and hypovolemia contribute to ischemia at the time of surgery and are associated with DGF [6–10]. Arterial blood pressure and volemia have to be optimized to effectively

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perfuse the graft immediately after completion of the vascular anastomosis [9]. On the other hand, patients with chronic renal failure are generally at high risk for cardiovascular disease, and volume expansion should be carefully monitored to avoid cardiac dysfunction and pulmonary edema. Thus, hemodynamics may easily oscillate between hypovolemia and hypervolemia, and the margin of safety with fluid administration is limited.

For several years, central venous pressure (CVP) monitoring has been proposed for intraoperative fluid management. A CVP of 10–15 mm Hg at the time of unclamping is often recommended in anesthetic management to maintain optimal intravascular volume during KT and to prevent graft failure [11,12]. However, recent literature analyses have challenged the usefulness of CVP to monitor fluid responsiveness during surgery and particularly during KT [10,13]. Pleth variability index (PVI) is an algorithm allowing automated and continuous monitoring of respiratory variations in the pulse oximetry plethysmographic waveform amplitude. PVI can predict fluid responsiveness noninvasively in mechanically ventilated patients during general anesthesia [14].

The aim of the present study was to compare intraoperative CVP and PVI values and to determine if either PVI or CVP could be helpful in predicting DGF.

METHODS

This was a prospective, noninterventional, observational, single-center study performed on all consecutive adult patients who underwent KT (deceased donors) from August 2012 to February 2013. Ethical approval was granted by the Ethics Committee, "Comité de Protection des Personnes," at Strasbourg University Hospital, Strasbourg, France on May 9, 2012. Subjects gave written informed consents.

Inclusion criteria required adult men or women (>17 years of age), scheduled for KT. Exclusion criteria were cardiac arrhythmia (PVI uninterpretable), impossibility to place the CVP line in the jugular or subclavicular vein, and pregnancy.

Perioperative Management

Patients were usually admitted to the hospital 3–8 hours before surgery. Hemodialysis was performed if the patient had not been dialyzed for >24 hours or if fluid overload or hyperkalemia was present; patients on peritoneal dialysis continued to follow their dialysis schedule.

All patients received similar general anesthesia and transplantation procedures performed by the same surgical team with the use of standard intraoperative protocols. Anesthesia was induced with the use of propofol (2.5–3 mg/kg), sufentanil (0.2–0.3 mg/kg), and cisatracurium (0.15 g/kg) or atracurium (0.5 mg/kg). After tracheal intubation, patients were mechanically ventilated with the use of a tidal volume of 8–10 mL/kg and a respiratory rate adjusted to obtain an end-tidal CO_2 level of 30–35 mm Hg. The positive end-expiratory pressure (PEEP) was set at 0–5 cm H_2O. Anesthesia was maintained by means of sufentanil target-controlled infusion and with 4.0–10.0 volume-% desflurane in 50% oxygen and air mixture. The bispectral index was maintained between 40 and 60. A central venous catheter (14 G, length 15 cm, Leader-Cath 2; Vygon, France) was inserted into the right internal jugular vein and an adhesive spectrophotometry digital sensor connected to a pulse CO-Oximeter (Masimo Radical-7, single-patient-use finger sensor Adtx; Masimo Corp, Irvine, California) was set up on the contralateral hand of a possible arteriovenous fistula.

Before releasing the clamps on the transplant vessels, all patients received 500 mg hydrocortisone and 250 mg furosemide. Neither dopamine nor mannitol were used.

Patients received induction therapy with anti–interleukin-2 receptor antibodies or thymoglobulin. Thereafter, immunosuppression was based on a combination of calcineurin inhibitor, mycophenolate mofetil, and corticosteroids.

Hemodynamic Management

Volume management included fluid load with crystalloids, normal saline solution, and colloids (albumin 4%). Patients received 15 mL/kg/h from the start of the surgery until the renal artery was unclamped after completion of the vascular anastomosis. Albumin 4% was used as additional fluid load when CVP was under a target value of 10 mm Hg before renal artery unclamping.

Fluids (crystalloids and albumin 4%) were given to obtain a CVP of 10–15 mm Hg before unclamping the renal artery, as has been recommended [11,12] and used in clinical studies [9,15,16].

The PVI monitor was not visible to the anesthetist, and PVI values were recorded but not provided to the anesthetist. Thus, the anesthetist was blind to the PVI values and volemia was managed only with CVP values.

Delayed and Immediate Graft Function

Immediate graft function (IGF) was defined as a reduction of ≥10% in serum creatinine within 48 hours following KT. DGF was defined as the absence of ≥10% reduction in serum creatinine within 48 hours following KT [2,17]. This definition of DGF is thought to be more sensitive than the requirement for dialysis during the 1st week after KT [2,18,19]. Dialysis required before day 2 was also considered to define DGF.

Parameters

Donor, Graft, Recipient, and Transplantation Characteristics. Demographic information were collected from recipients and donors: sex, age, the American Society of Anesthesiology (ASA) score (recipient), presence of hemodialysis for recipient, donor's arterial hypertension history, and donor's maximal serum creatinine and HLA mismatch. We also calculated the score proposed by Nyberg et al to assess donor organs [20]. This score uses 5 donor variables: age (0–25 points), history of hypertension (0–4), creatinine clearance before organ recovery (0–4), cause of death (0–3), and HLA mismatch (0–3). Deceased-donor kidneys were stratified by cumulative donor score: grade A (0–9 points), grade B (10–19), grade C (20–29), and grade D (30–39). The influence of donor score on renal function and graft survival was most severe above 20 points, designating "marginal" kidneys [20]. Cold ischemia time and surgery duration were recorded.

Early Renal Function After Kidney Transplantation. Serum creatinine and urine output levels, the need for a dialysis, and the number of dialysis sessions were recorded daily within the 1st postoperative week. The change of creatinine was calculated as the difference in serum creatinine over the 48 hours following KT.

Hemodynamic Parameters. Intraoperative hemodynamic parameters such as heart rate (HR); systolic, diastolic, and mean arterial pressure (MAP), PVI, and CVP were recorded at 5 time

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