

CASE REPORT

Recent Less-invasive Circulatory Monitoring during Renal Transplantation

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Abstract : For anesthetic management during renal transplantation, it is necessary to maintain the blood flow and function of the transplanted kidney by performing massive fluid management and stabilizing blood pressure. We report anesthetic management for renal transplantation with a less-invasive circulatory monitoring system (Edwards Life Sciences Co., Ltd., Irvine, California, U.S.A.). In November 2010, renal transplantation was started in our hospital, and performed in 6 patients. In the first patient, fluid/circulatory management was conducted by connecting a standard arterial line and a standard central venous (CV) line. In the second patient, a FloTrac™ system and a standard CV line were used. In the third patient, a standard arterial line and a PreSep™ CV Oximetry Catheter were used. In the fourth and fifth patients, a FloTrac™ and a PreSep™ were used. In the latest patient, FloTrac™ and PreSep™ were connected to an EV1000™ Clinical Platform for fluid/circulatory management. The establishment of high-visibility monitors was useful for evaluating the condition and confirming the effects. As there are marked changes in hemodynamics, the CV pressure, which has been used as a parameter of fluid management, is not reliable in renal failure patients with a high incidence of cardiovascular complications. Advances in noninvasive circulatory monitoring with dynamic indices may improve the safety of anesthetic management during renal transplantation. *J. Med. Invest.* 60 : 159-163, February, 2013

Keywords : renal transplantation, circulatory monitoring, fluid management, EV1000 clinical platform

INTRODUCTION

For anesthetic management during renal transplantation, it is necessary to maintain the blood flow and function of the transplanted kidney by performing massive fluid management and stabilizing the

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blood pressure from extirpation of the kidney to be transplanted until the completion of renal artery anastomosis (1). Recently, simple, less-invasive serial monitors have been developed/improved with marked advances in circulatory monitoring. FloTrac™ is a less-invasive, arterial pressure-based cardiac output-monitoring system. The stroke volume (SV) is estimated based on arterial pressure waveforms obtained from the radial artery, and multiplied by the pulse to express the cardiac output (CO) (2). Furthermore, respiration-related changes in the SV (stroke volume variation : SVV) are serially

expressed. SVV may become a parameter of optimized hemodynamics and fluid responsiveness (3). In addition, the use of a PreSepTM central venous (CV) oximetry catheter facilitates the serial monitoring of central venous oxygen saturation (ScvO₂) (4).

We report anesthetic management for renal transplantation with a less-invasive circulatory monitoring system (Edwards Life Sciences Co., Ltd., Irvine, California, U.S.A.) which is used in our hospital.

CASE REPORTS

In November 2010, renal transplantation was started in our hospital, and performed in 6 patients (donated kidney : 1 patient, brain death : 1, and living : 4, age : 18 to 60 years). The patient background is shown in Table 1. In the first patient, fluid/circulatory management was conducted by connecting a standard arterial line and a standard CV line. In the second patient, a FloTracTM system and a standard CV line were used. In the third patient, a standard arterial line and a PreSepTM CV oximetry catheter were used. In the fourth and fifth patients, a FloTracTM system and a PreSepTM CV oximetry catheter were used. In the latest patient, a FloTracTM system and PreSepTM CV oximetry catheter were connected to an EV1000TM Clinical Platform for fluid/circulatory management.

The most recent patient was a 49-year-old male with chronic renal failure. Living renal transplantation was performed (the donor was his wife).

Complications included ischemic heart disease, hypertension, diabetes, cerebral infarction, and abdominal aortic stenosis. Anesthesia was induced with remifentanil and propofol. After achieving muscle relaxation with rocuronium bromide, general anesthesia was induced through tracheal intubation. Subsequently, arterial (FloTracTM) and CV (PreSepTM CV oximetry catheter) lines were inserted, and connected to an EV1000TM Clinical Platform to start serial monitoring. As a monitoring screen, cockpit or physio-view monitors were primarily used. The cardiac output (CO), cardiac index (CI), stroke volume variation (SVV), stroke volume index (SVI), central venous oxygen saturation (ScvO₂), and systemic vascular resistance index (SVRI) were comprehensively evaluated, and used as parameters of fluid/circulatory management. Concerning vital signs after the start of surgery, blood pressure (BP) was 107/52 mmHg, heart rate (HR) was 71 bpm, CO was 4.8 L/min, CI was 2.6 L/min/m², SVV was 6%, SVI was 4.1 ml/beat/m², ScvO₂ was 71%, and CVP was 10 mmHg (Fig. 1). To manage the decrease in blood pressure, phenylephrine and ephedrine were administered in the absence of fluid loading, and dopamine therapy at 2 µg/kg/min was started to maintain the blood pressure until bench surgery. The kidney was extirpated from the donor 4 hours after the start of surgery. Fluid loading was initiated at the start of perfusion. With respect to vital signs before fluid loading, the BP was 106/52 mmHg, HR was 108 bpm, CO was 6.9 L/min, CI was 4.0 L/min/m², SVV was 22%, and CVP was 10 mmHg under dopamine therapy at 2 µg/kg/min. Establishing a target SVV of 10% or less, fluid loading at a total of

Table 1. Summary of 6 patients who underwent renal transplantation in Tokushima University hospital

Case	1	2	3	4	5	6
Indication	Brain death	Living	Living	Donated kidney	Living	Living
Age, yr	52	18	46	60	24	49
Weight, kg	55.5	44.5	48.3	65.9	54.8	70.9
Duration of surgery, min	323	465	360	408	361	476
Duration of anesthesia, min	413	540	426	517	444	563
Flo Trac TM	-	+	-	+	+	+
PreSep TM	-	-	+	+	+	+
EV1000 TM	-	-	-	-	-	+
Fluid until bench surgery/weight, ml/kg	37.8	60.7	31.0	17.5	20.1	16.9
Fluid from bench surgery until initial urine confirmation/weight, ml/kg	-	40.5	33.1	-	40.3	26.8
Total fluid/weight, ml/kg	81.1	139.3	110.7	45.5	100.9	56.4



Fig. 1 : Cockpit monitor after the start of surgery
CI ; cardiac index, SVV ; stroke volume variation, SVI ; stroke volume index, ScvO₂ ; central venous oxygen saturation

approximately 3,000 ml was performed before anastomosis of the renal artery. When the BP, HR, CI, SVV, SVI, ScvO₂, and CVP reached 118/51 mmHg, 107 bpm, 5.6 L/min/m², 7%, 51 mL/beat/m², 79%, and 12 mmHg, respectively, under dopamine therapy at 2.5 µg/kg/min, the vascular clamp was opened (Fig. 2). The decrease in the blood pressure after opening was slight, and there were slight changes in the SVV. Initial urine was confirmed after 40 minutes. A urine volume of 3 ml/kg/hr was maintained until the completion of surgery. The hemodynamics at the completion of surgery were stable : BP, 147/63 mmHg ; HR, 101 bpm ;

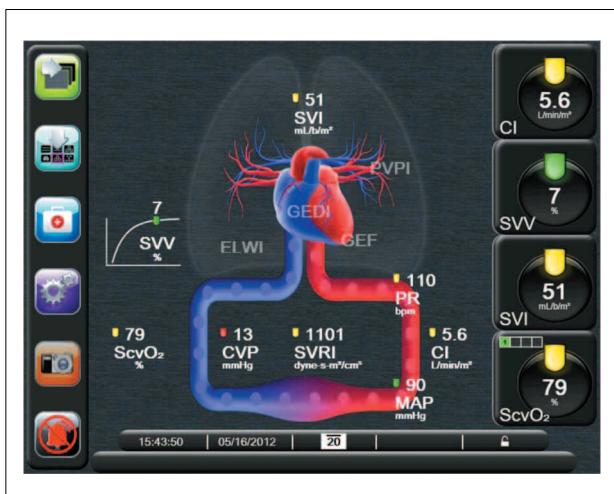


Fig. 2 : Physio-view monitor at the time the vascular clamp was opened
CI ; cardiac index, SVV ; stroke volume variation, SVI ; stroke volume index, ScvO₂ ; central venous oxygen saturation, CVP ; central venous pressure, SVRI ; systemic vascular resistance index, PR ; pulse rate, MAP ; maximum arterial pressure

CI, 5.3 L/min/m² ; SVV, 12% ; SVI, 53 mL/beat/m² ; ScvO₂, 75% ; and CVP, 11 mmHg. The postoperative course was favorable.

DISCUSSION

For anesthetic management during renal transplantation, it is important to promote the transplanted kidney function and maintain an adequate volume of blood flow in the transplanted kidney to prevent acute tubular necrosis (1). During renal transplantation, monitoring is commonly conducted using electrocardiogram, blood pressure, arterial line, central venous pressure, end-tidal CO₂ (ETCO₂), pulse oximeter, and body temperature. However, cardiac hypofunction is frequent in patients with renal failure (5, 6). Furthermore, a pulmonary artery catheter should be inserted, if necessary, to measure the pulmonary arterial pressure/cardiac output and perform fluid management, as the number of diabetic patients has increased (7). However, a pulmonary artery catheter may cause complications (8). For circulatory monitoring during renal transplantation, invasive arterial and central venous pressures have been primarily used. However, hemodialysis is performed in most patients undergoing renal transplantation, and cardiovascular complications are present ; the central venous pressure may not be an accurate parameter in some cases (9).

As a method of circulatory management, there is the entity of goal-directed therapy (GDT), a so-called, “goal-targeting treatment” (10, 11). In particular, individualized GDT in circulatory management during anesthesia has recently been used. This refers to patient-matched, SV-/CO-based circulatory/fluid management in which oxygen supply meeting tissue oxygen demand is maintained, but not the administration of a specific volume of fluid based on parameters such as blood pressure, pulse, and urine volume (12). This therapy reduces the doses of vasoconstrictors/catecholamines, and reduces the incidence of postoperative complications, shortening the admission period (12, 13). The FloTrac™ system is appropriate for individualized GDT. Flow-based dynamic indices such as the CO, SV, and SVV are more useful than pressure information-based management.

Flo Trac™ is a less-invasive, arterial pressure-based cardiac output-monitoring system developed by Edwards Life Sciences Co., Ltd. In Japan, it

became clinically available in April 2006. The arterial pressure-based CO is based on the principle that the aortic pressure is proportional to the SV, but inversely proportional to aortic compliance. Many studies have reported the accuracy of arterial pressure-based CO monitors (2). Furthermore, SVV is the most reliable predictor of optimized hemodynamics and fluid responsiveness. Many studies have reported its accuracy (3, 14, 15). In addition, the use of a PreSepTM CV Oximetry Catheter (for adults) or PediaSatTM Oximetry Catheter (for children) facilitates the serial monitoring of central venous oxygen saturation (ScvO₂) (4). ScvO₂ changes in parallel to SvO₂ (16). As ScvO₂ depends on the CO/hemoglobin level/arterial blood oxygen saturation involved in oxygen transport, as well as metabolism involved in oxygen consumption, continuous monitoring of the oxygen demand/supply balance is possible (17). Continuous monitoring of ScvO₂ enabled evaluation of the oxygen supply to tissues to help determine the need for blood transfusion.

We performed circulatory management during renal transplantation using a less-invasive circulatory monitoring system. In the sixth case, the latest EV1000TM Clinical Platform was available, facilitating individualized GDT based on the CO, SVV, SVR, and ScvO₂, in addition to CVP. The establishment of high-visibility monitors was useful for evaluating the condition and confirming the effects. The color-coded image of the target on cockpit monitors facilitated visual/intuitive assessment of the patient's condition. Physio-view monitors made it possible to understand the interrelationships among the heart, blood, and vascular system through animation. As a result, intraoperative management at a fluid volume smaller than previously used was achieved (Table 1). For renal transplantation, it is necessary to restrict fluid management using a vasopressor until bench kidney surgery and start rapid fluid loading during anastomosis of the renal artery/vein. However, most patients with chronic renal failure do not have any heart reserve to promptly receive a massive volume of fluid in a relatively short interval during surgery. A close circulatory monitoring system is essential. The use of the EV1000TM Clinical Platform facilitated appropriate GDT. The EV1000TM clinical platform (with FloTracTM and PreSepTM) provided reliable information for the intraoperative management of high risk patients during renal transplantation without the need for an invasive pulmonary artery catheter. Goal-directed

hemodynamic and fluid optimization using a less-invasive circulatory monitoring system may result in improved outcomes.

CONCLUSION

As there are marked changes in hemodynamics, the CVP, which has been used as a parameter of fluid management, is not reliable in renal failure patients with a high incidence of cardiovascular complications. Advances in less-invasive circulatory monitoring with dynamic indices (the EV1000TM Clinical Platform) may improve the safety of anesthetic management during renal transplantation. In the future, additional monitoring items, such as the extra-vascular lung water (EVLW) system may contribute to more comprehensive circulatory management. In addition, much less-invasive monitoring methods will be developed leading to marked changes in the renal transplantation area. Anesthesiologists must acquire broad, deep knowledge of the above methods, including those of the perioperative period.

REFERENCES

1. SarinKapoor H, Kaur R, Kaur H : Anaesthesia for renal transplant surgery. *Acta Anaesthesiol Scand* 51 : 1354-1367, 2007
2. Mayer J, Boldt J, Wolf MW, Lang J, Suttner S : Cardiac output derived from arterial pressure waveform analysis in patients undergoing cardiac surgery : validity of a second generation device. *Anesth Analg* 106 : 867-872, 2008
3. Hofer CK, Müller SM, Furrer L, Klaghofer R, Genoni M, Zollinger A : Stroke volume and pulse pressure variation for prediction of fluid responsiveness in patients undergoing off-pump coronary artery bypass grafting. *Chest* 128 : 848-854, 2005
4. Collaborative Study Group on Perioperative ScvO₂ Monitoring : Multicentre study on peri- and postoperative central venous oxygen saturation in high-risk surgical patients. *Crit Care* 10 : R158, 2006
5. Parfrey PS, Foley RN, Harnett JD, Kent GM, Murray DC, Barre PE : Outcome and risk factors for left ventricular disorders in chronic uraemia. *Nephrol Dial Transplant* 11 : 1277-1285, 1996

6. Sarnak MJ, Levey AS, Schoolwerth AC, Coresh J, Culleton B, Hamm LL, McCullough PA, Kasiske BL, Kelepouris E, Klag MJ, Parfrey P, Pfeffer M, Raji L, Spinosa DJ, Wilson PW : Kidney disease as a risk factor for development of cardiovascular disease : a statement from the American Heart Association Councils on Kidney in Cardiovascular Disease, High Blood Pressure Research, Clinical Cardiology, and Epidemiology and Prevention. *Circulation* 108 : 2154-2169, 2003
7. De Gasperi A, Narcisi S, Mazza E, Bettinelli L, Pavani M, Perrone L, Grugni C, Corti A : Perioperative fluid management in kidney transplantation : is volume overload still mandatory for graft function? *Transplant Proc* 38 : 807-809, 2006
8. American Society of Anesthesiologists task force on pulmonary artery catheterization : Practice guidelines for pulmonary artery catheterization : An updated report by the American Society of Anesthesiologists task force on pulmonary artery catheterization. *Anesthesiology* 99 : 988-1014, 2003
9. Ohara T, Hashimoto Y, Matsumura A, Suzuki M, Isobe M : Accelerated progression and morbidity in patients with aortic stenosis on chronic dialysis. *Circ J* 69 : 1535-1539, 2005
10. Mayer J, Boldt J, Mengistu AM, Röhm KD, Suttner S : Goal-directed intraoperative therapy based on autocalibrated arterial pressure waveform analysis reduces hospital stay in high-risk surgical patients : a randomized, control trial. *Crit Care* 14 : R18, 2010
11. Rivers E, Nguyen B, Havstad S, Ressler J, Muzzin A, Knoblich B, Peterson E, Tomlanovich M : Early goal-directed therapy in the treatment of severe sepsis and septic shock. *N Engl J Med* 345 : 1368-1377, 2001
12. Bundgaard-Nielsen M, Holte K, Secher NH, Kehlet H : Monitoring of peri-operative fluid administration by individualized goal-directed therapy. *Acta Anaesthesiol Scand* 51 : 331-340, 2007
13. Goepfert MS, Reuter DA, Akyol D, Lamm P, Kilger E, Goetz AE : Goal-directed fluid management reduces vasopressor and catecholamine use in cardiac surgery patients. *Intensive Care Med* 33 : 96-103, 2007
14. Biais M, Nouette-Gaulain K, Cottenceau V, Revel P, Sztark F : Uncalibrated pulse contour-derived stroke volume variation predicts fluid responsiveness in mechanically ventilated patients undergoing liver transplantation. *Br J Anaesth* 101 : 761-768, 2008
15. Cannesson M, Musard H, Desebbe O, Boucau C, Simon R, Hénaine R, Lehut JJ : The ability of stroke volume variations obtained with Vigileo/FloTrac system to monitor fluid responsiveness in mechanically ventilated patients. *Anesth Analg* 108 : 513-517, 2009
16. Reinhart K, Kuhn HJ, Hartog C, Bredle DL : Continuous central venous and pulmonary artery oxygen saturation monitoring in the critically ill. *Intensive Care Med* 30 : 1572-1578, 2004
17. Reinhart K, Bloos F : The value of venous oximetry. *Curr Opin Crit Care* 11 : 259-263, 2005