

CASE REPORT

Effectiveness of using non-invasive continuous arterial pressure monitoring with ClearSight in hemodynamic monitoring during living renal transplantation in a recipient : a case report

Nami Kakuta, Yasuo M. Tsutsumi, Chiaki Murakami, Yoko Sakai, Takuro Oyama, Asuka Kasai, Katsuyoshi Kume, and Katsuya Tanaka

Department of Anesthesiology, Tokushima University 3-18-15 Kuramoto, Tokushima, 770-8503, Japan

Abstract : We investigated the effectiveness of the ClearSight system for hemodynamic management during kidney transplantation for a recipient. The recipient was to receive a kidney transplant from his mother under general anesthesia. We used continuous noninvasive finger-cuff-based monitoring of blood pressure, provided by the ClearSight system, and stroke volume variation to predict fluid responsiveness. We used of a balanced anesthetic technique and stringent monitoring standards to ensure a successful outcome for the patient. This case demonstrated that ClearSight has the potential to improve patient monitoring in hemodynamically stable patients who received kidney transplantation under general anesthesia. *J. Med. Invest.* 65 : 139-141, February, 2018

Keywords : *ClearSight system, finger cuff, noninvasive, renal transplant recipient*

INTRODUCTION

Renal transplantation is important for hemodynamic management and fluid volume control (1). We usually use continuous hemodynamic monitoring, arterial line (A-line) and central venous catheter (CVC), as a guide fluid management and to adjust inotropic and/or vasopressor agents. However, both A-line and CVC require invasive catheters.

The ClearSight system (Edwards Lifesciences Cop, Irvine, CA, USA) is a device used for measuring arterial blood pressure continuously and noninvasively through finger-cuffed technology (2). Not only finger-cuff-based monitoring of blood pressure (FBP), but the ClearSight system provide heart rate (HR), stroke volume (SV), cardiac output (CO), cardiac index (CI), stroke volume index (SVI), stroke volume variation (SVV), systemic vascular resistance (SVR), and systemic vascular resistance index (SVRI) (3). It is noninvasive measurement.

Therefore, we investigated the ClearSight system may be usefulness in renal transplantation recipient as a reliable and totally noninvasive method of fluid measurement without CVC.

CASE REPORT

The recipient of the renal transplantation in this study was a 41-year-old male, with a weight of 91.2 kg and height of 163.5 cm with end-stage renal failure. He had a history of multicystic renal cyst, multicystic liver cyst, and hypertension. His routine blood reports were normal, except for renal dysfunction (BUN 36.3 mg/dl, Cr 7.29 mg/dl). The patient's electrocardiogram (ECG) showed a soli-

tary T-wave inversion in III. The chest X-ray was normal. His echocardiography report showed that he had a functional left ventricle with an ejection fraction of 75%, mild left ventricular (LV) hypertrophy, and LV diastolic dysfunction, and not reduced cardiac function. He started hemodialysis in November 2016 from a distal radiocephalic arteriovenous fistula (AVF) on the left arm. Because of the symptoms of nausea and vomiting, the patient experienced after every hemodialysis, treatment was shortened. It was determined that he could receive renal transplant from his mother, under general anesthesia. His intravenous access was established using an 18-G cannula on the right hand. After a radial artery was cannulated (A-line), the figure cuff of the ClearSight device (Edwards Lifesciences Cop, Irvine, CA, USA) was placed around the patient's right hand index finger. Pulse oximetry, ECG, non-invasive blood pressure (NBP), end tidal CO₂, core body temperature by a rectum probe, hourly urine output, and finger-cuff-based monitoring of blood pressure (FBP), cardiac output (CO), stroke volume variation (SVV) were measured.

Anesthesia was induced with DIV remifentanyl 0.3 µg/kg/min and IV propofol 1 mg/kg. Intubation was facilitated with IV rocuronium 60 mg. Anesthesia was maintained with sevoflurane, O₂, air, and rocuronium as the muscle relaxant, in combination with remifentanyl 0.1-0.3 µg/kg/min and fentanyl. We managed the fluid volume with SVV obtained with the ClearSight to predict fluid responsiveness. Stroke volume variation may be a useful parameter to predict hypovolemia and fluid responsiveness during renal transplantation (3).

Until clamping the renal artery, the infusion volume is the maintenance volume and the bleeding volume. We maintained FBP 90/55 mmHg, heart rate (HR) 60 bpm, SVV 12%, stroke volume (SV) 86 mL/b and CO 5.2 L/min. As SVV is modified by lung compliance and ventilatory management, we setted ventilatory control to tidal volume 600 mL, positive end-expiratory pressure 0 mmHg, and peak airway pressure 18mmHg. We usually managed, before declamping the renal artery, a central venous pressure (CVP) of 12-15 mmHg were ensured with the help of generous hydration. In

Received for publication September 6, 2017 ; accepted October 13, 2017.

Address correspondence and reprint requests to Nami Kakuta, M.D., Ph.D. Department of Anesthesiology, Tokushima University 3-18-15, Kuramoto, Tokushima 770-8503, Japan and Fax : +81-88-633-7182.

this case, CVC was not inserted, we defined systolic FBP as being maintained above 120 mmHg and SVV of 4-6% of increasing SV and CO, instead of CVP. This volume expansion is associated with increased renal blood flow and improved graft function. Just before anastomosis and clamp release, we decreased the SVV by 4% (absolute percentage value), increased SV and CO, and maintained FBP to provide adequate perfusion to the transplanted kidney. We maintained FBP at 120-136/65-70 mmHg, HR 68-76 bpm, SVV 4-6%, SV 106-120 mL/b and CO 7.2-9.7 L/min. Furosemide was given to improve graft viability and ensure diuresis. The patient's systolic FBP was kept above 120 mmHg until the end of the surgery, and about 3000 mL of crystalloids and 100 mL of colloids (20% human serum albumin) were infused. There was adequate urine output of 900 mL per hour after reperfusion. The patient was extubated uneventfully, after complete reversal of muscle paralysis. We made use of a balanced anesthetic technique and stringent monitoring standards to ensure a successful outcome for the patient. On the 11 postoperative day, the patient went home with a healthy functioning kidney (BUN 35.7 mg/dl, Cr 2.45 mg/dl).

flatable cuff placed around a finger (Figure 1). This measures finger arterial pressure directly from the finger cuff using a volume-clamp method, from which brachial arterial pressure is reconstructed using waveform filtering with pressure level correction (4). The ClearSight system provide continuous noninvasive FBP, HR, SV, CO, cardiac index (CI), stroke volume index (SVI), SVV, systemic vascular resistance (SVR), and systemic vascular resistance index (SVRI). Stroke volume is estimated based on arterial pressure waveforms obtained from the finger artery, and multiplied by the pulse to express CO (3). Respiration-related changes in the SV (SVV) are serially expressed. Stroke volume variation may become a parameter of optimized hemodynamics and fluid responsiveness (3).

DISCUSSION

Renal transplantation is important for hemodynamic management and fluid volume control. Our goals for perioperative management were to maintain stable hemodynamics throughout the procedure, perform adequate infusion, maintain perfusion for the transplanted solitary kidney, and to provide adequate analgesia for the patient. Therefore, continuous hemodynamic monitoring, A-line and CVC, is of use as a guide fluid management and to adjust inotropic and/or vasopressor agents. However, both A-line and CVC require invasive catheters and therefore increase the risk of catheter infection, bleeding, deep venous thrombosis, and pneumothorax (2).

The ClearSight system uses photoplethysmography and an in-



Fig 1. The ClearSight device

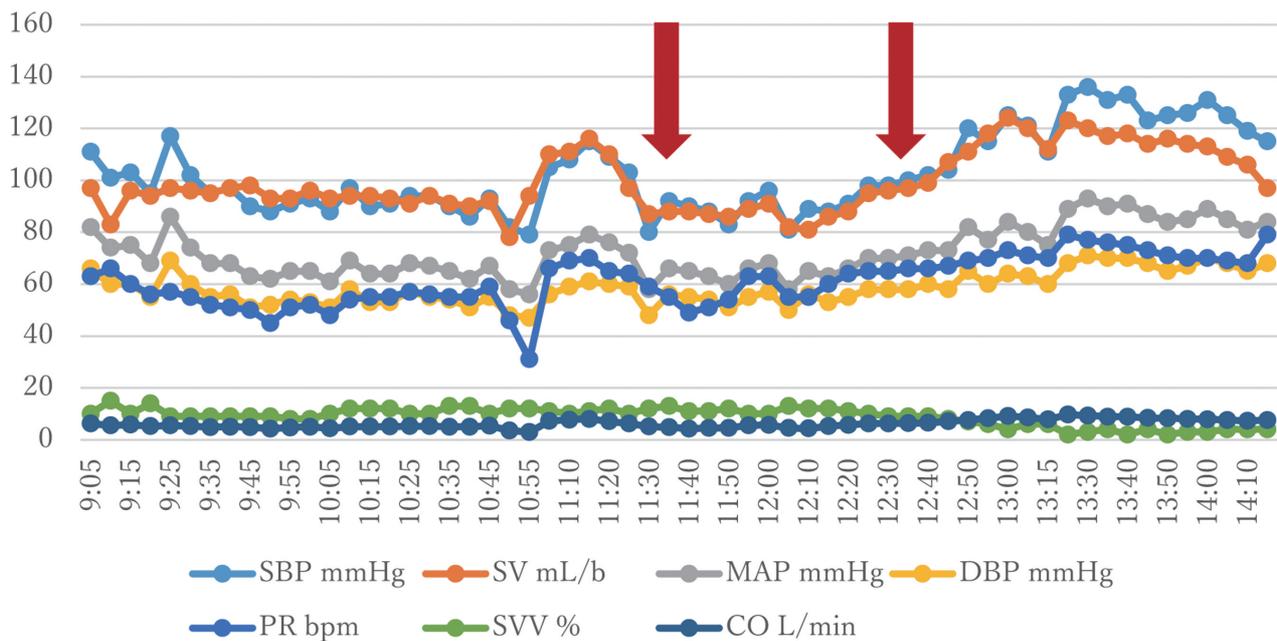


Fig 2. Vital record with ClearSight. First arrow shows the renal artery clamped. Second arrow is the renal artery declamped. SBP = systolic blood pressure, mmHg. SV = stroke volume, mL/b. MAP = mean arterial pressure, mmHg. DBP = diastolic blood pressure, mmHg. PR = pulse rate, bpm. SVV = stroke volume variation, %. CO = cardiac output, L/min.

Our main goal during the renal transplantation, to promote the function of the transplanted kidney and maintain an adequate volume of blood flow in the transplanted kidney to prevent acute tubular necrosis(5). Therefore, before clamping the renal artery, we managed a normal FBP and a SVV of 10-13% using the ClearSight system. After declamping, the kidney was perfused, maintained at a high normal FBP and co-hydration to maintain kidney blood flow, to get urine volume, SVV decreased by 4-6% (absolute percentage value). Although we used SVV to fluid volume control, it should be management from correlation between SVV and SVI. Further research is needed to determine whether this management (SVV of 4-6% of increasing SV and CO) is optimal to prevent the postoperative acute tubular necrosis.

The accuracy of FBP compared with NBP and invasive blood pressure was not inferior in this case. The bias between ClearSight was less than 5 mmHg with NBP and ABP. However, Hohn evaluated non-invasive continuous arterial pressure monitoring did not sufficiently replace invasive measurements in critically ill patients (6). In their study, critically ill patients experienced edema and had continuous norepinephrine administration that may have reduced peripheral blood flow, affecting the non-invasive measurements. Our patient had adequate cardiac function and was not in the critically ill state, ClearSight was a reliable monitor, but, further study is needed using various patients.

In fully sedated and mechanically ventilated patients, SVV can be considered as a reliable monitor of fluid responsiveness(2). Stroke volume variation is the most reliable predictor of optimized hemodynamics and fluid responsiveness, many studies have reported its accuracy (7-9). In this case, we did not use the CVC to reduce invasive catheters. It might be more better to compare SVV and CVP. It would have been interesting to know how the SVV-guided fluid management affected CVP (10).

Recent studies have shown the feasibility of noninvasive and continuous blood pressure measurements during surgical procedures. However, accuracy and precision are still debated (11). This case demonstrated ClearSight has potential to improve patient monitoring in hemodynamically stable patients who receive kidney transplantation under general anesthesia. However, further studies are needed to provide reliable information for the intraoperative management of high risk patients during renal transplantation without the need for invasive arterial cannulation and central venous catheter.

In addition, we have used the ClearSight in living renal transplantation. We think that it is also useful in cadaveric renal transplantations. Transfusion management of cadaveric renal transplantation is more difficult than living renal transplantation. Because oliguria often continues even after surgery, it does not load infusion easily (12). We also want to evaluate the effectiveness of the ClearSight device in cadaveric renal transplantations.

CONCLUSION

ClearSight is a less-invasive circulatory monitoring system that may improve the safety of anesthetic management during renal transplantation. Further research, with the use of the ClearSight device, in renal transplantation will help to determine the safety and efficacy.

CONSENT FOR PUBLICATION

For publication of this report, written consent was obtained from patient.

COMPETING INTERESTS

The authors declare that they have no competing interests.

REFERENCES

1. Baker J, Yost SC, Niemann UC : Miller's anesthesia. 6th ed. Philadelphia : Churchill Livingstone ; Organ transplantation ; pp. 2240-2241, 2005
2. Ameloot K, Palmers PJ, Malbrain MK : The accuracy of noninvasive cardiac output and pressure measurements with finger cuff : a concise review. *Curr Opin Crit Care* 21 : 232-9, 2015
3. Soga T, Kawahito S, Oi R, Kakuta N, Katayama T, Wakamatsu N, *et al* : Recent less-invasive circulatory monitoring during renal transplantation. *J Med Invest* 60 : 159-63, 2013
4. Sng BL, Wang H, Assam PN, Sia AT : Assessment of an updated double-vasopressor automated system using Nexfin for the maintenance of haemodynamic stability to improve peri-operative outcome during spinal anaesthesia for caesarean section. *Anaesthesia* 70 : 691-8, 2015
5. Sarin Kapoor H, Kaur R, Kaur H : Anaesthesia for renal transplant surgery. *Acta Anaesthesiol Scand* 51 : 1354-67, 2007
6. Hohn A, Defosse JM, Becker S, Steffen C, Wappler F, Sakka SG : Non-invasive continuous arterial pressure monitoring with Nexfin does not sufficiently replace invasive measurements in critically ill patients. *Br J Anaesth* 111 : 178-84, 2013
7. 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 : 761-8, 2008
8. Cannesson M, Musard H, Desebbe O, Boucau C, Simon R, Henaine R, *et al* : The ability of stroke volume variations obtained with Vigileo/FloTrac system to monitor fluid responsiveness in mechanically ventilated patients. *Anesth Analg* 108 : 513-7, 2009
9. Slagt C, Malagon I, Groeneveld AB : Systematic review of uncalibrated arterial pressure waveform analysis to determine cardiac output and stroke volume variation. *Br J Anaesth* 112 : 626-37, 2014
10. Ferris RL, Kittur DS, Wilasrusmee C : Early hemodynamic changes after renal transplantation : determinants of low CVP in the recipients and correlation with acute renal dysfunction. *Med Sci Monit* 9 : 61-66, 2003
11. Martina JR, Westerhof BE, van Goudoever J, de Beaumont EM, Truijzen J, Kim US, *et al* : Noninvasive continuous arterial blood pressure monitoring with Nexfin®. *Anesthesiology* 116 : 1092-103, 2012
12. Potura E, Lindner G, Biesenbach P, Funk GC, Reiterer C, Kabon B, *et al* : An acetate-buffered balanced crystalloid versus 0.9% saline in patients with end-stage renal disease undergoing cadaveric renal transplantation : a prospective randomized controlled trial. *Anesth Analg* 120 : 123-9, 2015