

## CASE REPORT

# Usefulness of the ClearSight System in Monitoring Patients with End-Stage Renal Stage: Two Case Reports

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Since blood pressure tends to be unstable during surgery, an arterial catheter is often inserted to monitor arterial pressure continuously during general anesthesia. However, there are some situations wherein arterial cannulation is not allowed. ClearSight System enables noninvasive continuous monitoring of arterial pressure and derives variables via a single finger cuff without arterial cannulation. We describe two cases of end-stage renal disease patients who were hemodynamically unstable during surgery. In these cases, rapid and appropriate management was possible using the ClearSight System in a situation where the arterial puncture was difficult.

**Keywords:** Arterial pressure; Blood pressure monitors; Chronic kidney failure; Case report

## INTRODUCTION

Patients often become hemodynamically unstable during surgeries due to underlying conditions, general anesthesia, and surgical manipulation [1]. Such instability may require continuous measurement of the arterial pressure by inserting an arterial catheter to monitor arterial pressure and waveforms [2]. These arterial pressure and waveforms may be used to obtain useful information, such as stroke volume variation (SVV) and cardiac index (CI), using the FloTrac system. However, the placement of a catheter in an artery may lead to several complications, including vascular damage or infection, blood clots and ischemia, and nerve damage, as well as chronic pain syndrome in rare cases [2]. In addition, the patient's condition or surgical situation may limit the placement of an arterial catheter. Diseases such as obesity, edema, severe hypotension, and arteriosclerosis present difficulties in the placement of an arterial line and are associated with a high risk of failure. In other cases, the placement of an arterial line is avoided. The radial artery is the most common artery for arterial catheter placement. To use the FloTrac system, the radial artery must be punctured. However, if there is insufficient collateral circulation,

radial artery puncture is unsafe. Furthermore, in patients with renal failure, severe arteriosclerosis may prevent the placement of an arterial catheter, and puncture of blood vessels in the arm, including the radial artery, may be prohibited for the formation of arteriovenous fistulas (AVF) in the future. In these situations, non-invasive continuous monitoring of arterial pressure may be a useful alternative. ClearSight System (Edwards Lifesciences Corp., Irvine CA, USA) can continuously measure arterial pressure and waveforms through a finger cuff in a non-invasive manner (Fig. 1). The system can be connected to an EV1000 monitor (Edwards Lifesciences Corp.) for numerical monitoring of SVV and CI, similar to the FloTrac system. Herein, we have reported cases of rapid treatment of end-stage renal disease (ESRD) patients with hemodynamic instability who could not undergo arterial puncture, using the ClearSight System.

## CASE REPORT

### 1. Case 1

A 38-year-old man, weighing 77 kg with a height of 163 cm and a body mass index (BMI) of 29.0 kg/m<sup>2</sup>, was scheduled to undergo

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Received: Feb. 18, 2022 / Accepted after revision: May 2, 2022

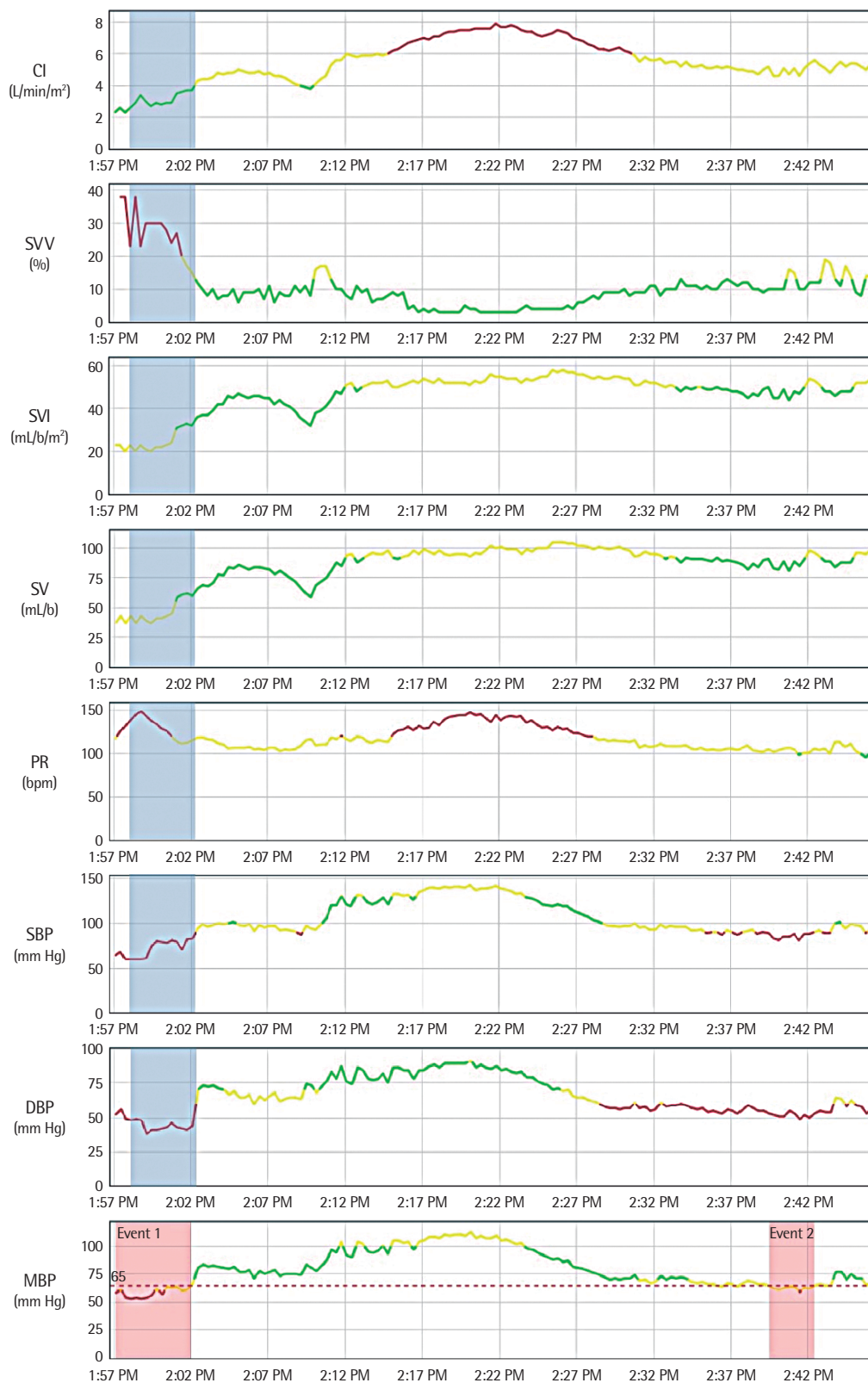
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**Fig. 1.** (A–C) ClearSight System (Edwards Lifesciences Corp., Irvine CA, USA) with monitoring platforms and finger cuff device.

open thrombectomy of AVF. The patient was previously diagnosed with hypertension; however, the patient was noncompliant with his anti-hypertensive medications and had been on hemodialysis since 1996 for ESRD. The patient had a cephazolin allergy, manifesting as rashes, itchiness, hypotension, and decreased oxygen saturation, and had a history of nausea and vomiting caused by contrast materials. A preoperative blood test showed a hemoglobin level of 11.9 g/dL and serum potassium of 4.5 mmol/L, and echocardiography revealed an ejection fraction (EF) of 70% and suggested grade I diastolic dysfunction. Prior to entering the operating room, 0.1 mg of glycopyrrolate was administered to the patient intramuscularly, and 1 g of vancomycin was diluted in 100 mL of normal saline (NS) to start intravenous infusion in the ward. The patient underwent open thrombectomy under general anesthesia 1 year prior. At that time, 1 g of vancomycin was infused intravenously as preoperative treatment. No specific signs were observed at that time. When the patient arrived at the operating room 10 minutes later, he complained of itching on the left arm and face. Redness was observed on the left arm. Drug allergy was suspected, and vancomycin administration was discontinued. Dexamethasone 5 mg and chlorpheniramine maleate 4 mg were

administered intravenously. The patient complained of nausea and mild dizziness; however, the symptoms had improved and vital signs were stable. Thus, the patient underwent general anesthesia, as scheduled. Initially, blood pressure (BP), heart rate, oxygen saturation, and temperature were 118/70 (87) mm Hg, 71 bpm, 100%, and 36.5°C, respectively. Anesthesia was induced using 4.5 mcg/mL of propofol and 1 ng/mL of remifentanyl in a target-controlled infusion mode. After administering rocuronium 0.5 mg/kg, a laryngeal mask airway was inserted. Subsequently, the concentration of propofol and remifentanyl was reduced to 3.5 mcg/mL and 0 ng/mL, respectively. The operation started with stable vital signs, 30 minutes after the patient entered the operating room. Once the operation began, the heart rate exceeded 100 bpm. Thus, remifentanyl 0.4 ng/mL was administered. After 5 minutes, BP and heart rate were 65/37 (49) mm Hg and 132 bpm, respectively, showing hypotension and aggravation of tachycardia. Phenylephrine 100 mcg was administered intravenously; however, no improvement was observed. Phenylephrine 100 mcg was administered again; however, the systolic BP (SBP) was between 60 mm Hg and 50 mm Hg, causing difficulties in palpating the pulse in the dorsal artery. The arteries could not be found even with ultra-



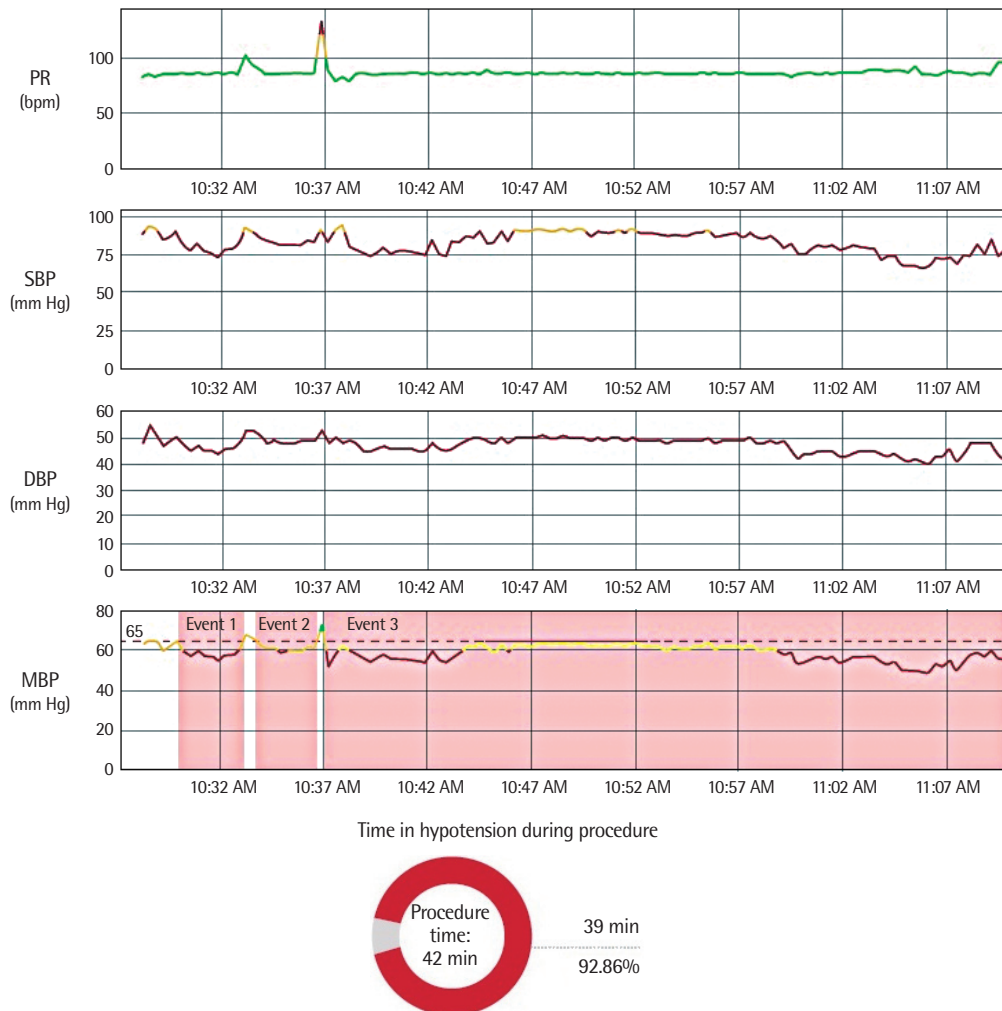
**Fig. 2.** Values measured during operation with ClearSight System. Blue box: normal saline 300 mL site of rapid infusion. Red box: hypotensive zone based on mean blood pressure (MBP) 65 mm Hg. Event 1 in the hypotensive zone, cardiac index (CI) is in the normal range; however, stroke volume (SV), stroke volume index (SVI), systolic blood pressure (SBP), diastolic blood pressure (DBP), and MBP are low while stroke volume variation (SVV) and pulse rate (PR) are high.

sound images, and the arterial catheter could not be placed. The arm could not be punctured due to the possible need for a new AVF. We decided to use ClearSight System and wrapped a cuff around the finger of the patient. CI was maintained at 2.3–2.6; however, stroke volume (SV) and stroke volume index (SVI) were low, and SVV was 30%–38% (Fig. 2). Subsequently, 300 mL of NS was rapidly administered intravenously to the patient in approximately 5 minutes. Hypotension and tachycardia were improved (Fig. 2). No bleeding was observed during the operation, and there was no urine output due to renal failure. Thus, the patient had limited fluid administration. Based on the monitored values, 300 mL of NS was further administered thereafter. A total of 600 mL of NS was administered during the operation. After the operation, vital signs were stable, and anesthesia was terminated. Following recov-

ery, the patient was instructed to stay in a leg elevation position in the ward. BP was 119/62 mm Hg, and heart rate was at 110 bpm. Vital signs were stable after dialysis in the afternoon on the first postoperative day. The patient was discharged as the vital signs were stable and no specific symptoms, such as pain and infection, were observed. The patient provided written informed consent for the publication of clinical details and images.

## 2. Case 2

An 86-year-old man, weighing 60 kg with a height of 160 cm and a BMI of 23.4 kg/m<sup>2</sup>, was scheduled to undergo partial resection of a graft vessel due to an axillary abscess caused by an AVF graft vessel infection in the left arm. The patient had hypertension and diabetes and had been on hemodialysis for 3 years for ESRD.



**Fig. 3.** Pulse and BP measurement during operation with ClearSight System. Red box: hypotensive zone based on mean blood pressure (MBP) 65 mm Hg and shows persistent hypotension during monitoring. PR, pulse rate; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Preoperative echocardiography showed findings of severe atrial and ventricular enlargement, severe left ventricular systolic dysfunction with EF 29%, grade I diastolic dysfunction, and aortic regurgitation. Arrhythmia was observed, and a pacemaker was inserted. BP, heart rate, and body temperature measured in the ward prior to the surgery were 139/66 mm Hg, 71 bpm, and 36.8°C, respectively. Immediately before anesthesia induction, BP, heart rate, and oxygen saturation were 130/51 (82) mm Hg, 85 bpm, and 100%, respectively. As the patient had severe cardiac dysfunction, general anesthesia was induced while cautiously observing the contraction of the heart with transthoracic echocardiography. Anesthesia was induced with propofol 3 mcg/mL and remifentanyl 1 ng/mL in target-controlled infusion mode. After administration of rocuronium 0.5 mg/kg, a laryngeal mask airway was inserted. The concentration of propofol was reduced to 1.5–2.0 mcg/mL afterward; however, after 20 minutes, echocardiography showed findings of decreased contractility and BP decreased continuously. Considering left ventricle size and contractility, fluid supplementation was not appropriate management. Dopamine was infused immediately at 7–12 mcg/kg/min. Continuous monitoring of the arterial pressure was required. Catheter puncture at the dorsal artery was risky as the patient had a history of occlusive arteriosclerosis in both legs. The arm was likely to be used as a new dialysis route in the future as well. Therefore, a cuff was wrapped around a finger, and ClearSight System was used for monitoring. As the patient had arrhythmia and valvular disease, SVV and other indexes were not reliable. However, continuously monitored arterial pressure and waveforms were useful to guide the treatment. Intermittent BP measurement of the upper arm was stopped as the non-invasive, continuous BP monitoring using a finger cuff on the same arm showed good compatibility. BP was monitored using the ClearSight System during the operation. Hypotension persisted throughout the operation (Fig. 3). Dopamine and anesthetic agents were adjusted to adequate concentrations accordingly. After the operation, dopamine was tapered and terminated on the first postoperative day. SBP and diastolic BP were maintained at 121–124 mm Hg and 50–55 mm Hg, respectively. The patient was discharged. The patient provided written informed consent for the publication of clinical details and images.

## DISCUSSION

ESRD patients have higher morbidity from cardiovascular dis-

eases, such as uncontrolled hypertension, arteriosclerosis, left ventricular hypertrophy, atrial & ventricular enlargement, and a high prevalence of hypovolemia due to fluid restrictions. Consequently, as seen in the presented cases, these patients have a high risk of hemodynamic instability, leading to difficulties in determining the cause or prioritizing treatment. Therefore, continuous monitoring of arterial pressure is frequently required, and indicators such as CI or SVV may provide useful information in such circumstances. However, as observed in our cases, the use of invasive monitoring is often difficult in ESRD patients. In this case, ClearSight System allows continuous, non-invasive measurement of arterial pressure and waveforms through a finger cuff using photoplethysmography technology [3]. As described in many previous studies, this is a reliable method of clinical monitoring [1,4-7].

In the first case, at the time of severe hypotension and tachycardia, ClearSight System showed findings of CI at 2.3–2.6 while SVV was high at 30%–39%. Although this is not a diagnostic criterion for hypovolemia, the patient was hemodynamically unstable. As both SV and SVI were low, high SVV indicated the need for active fluid treatment. Thus, although the patient had ESRD, we proceeded with rapid volume replacement therapy, and the patient's condition was improved. In the treatment of this ESRD patient, who has difficulties actively receiving fluid treatment due to poor BP control and renal dysfunction, the use of indicators such as CI and SVV was an important factor enabling rapid treatment.

The first patient showed symptoms such as redness, pruritus, nausea, and dizziness before the operation. These symptoms may have been caused by immunoglobulin E (IgE)-mediated anaphylaxis to the drugs administered before the operation. The patient shows no specific signs when vancomycin was administered a year prior. However, drug-specific IgE antibodies may have been generated, leading to IgE-mediated anaphylaxis here in our case. The symptoms may have been also caused by vancomycin infusion reaction (VIR). Redness, pruritus, and hypotension are symptoms of VIR and may be attributed to idiopathic reactions from the administration of vancomycin over a short span of time, leading to the secretion of histamine by mast cells. To prevent this, it is recommended to administer 1 g of vancomycin over at least 100 minutes. The patient may have been administered vancomycin at a faster rate than prescribed during the 10 minutes of transfer, which may have also contributed to VIR. Fluid therapy is also important for VIR and IgE-mediated anaphylaxis; however, vital signs must be corrected with the administration of epinephrine

first. In particular, in the case of our patient, infusing a large amount of fluid may be a burden for ESRD. If indicators such as CI and SVV are not available, fluid therapy is likely to be delayed. As invasive arterial catheter placement was not clinically feasible, the lack of ClearSight System would not have provided CI and SVV, leading to longer hemodynamic instability.

In the second patient, indicators such as CI and SVV were unreliable due to underlying conditions (arrhythmias and valvular disease) and could not be used for treatment. Severe ventricular dilatation decreased myocardial contractility, and continued hypotension indicated the need for continuous monitoring of arterial pressure and waveforms. Approximately 19.7% of invasive arterial puncture leads to complications [2]. The complications commonly include temporary occlusion of the radial artery and hematoma [2]. Other complications include infection, bleeding, sepsis, ischemia, and nerve damage [2]. This patient had a history of obstructive atherosclerosis, which may have increased the risk of occlusion or ischemia after an arterial puncture. In addition, the patient was undergoing an operation for underlying infection, suggesting that the patient was already vulnerable to infection and inflammatory reactions. The use of ClearSight System allowed continuous monitoring of the BP without invasive procedures that increase the risk of complications. Previous studies showed that this non-invasive device for continuous monitoring of arterial pressure was reliable in various clinical situations during surgery [5-7]. Although the device was not accurate enough to replace the invasive arterial pressure monitoring using arterial catheterization, the device was reliable in rapidly detecting variations in the arterial pressure [3]. Additionally, the results report of this monitoring shows the frequency and duration of hypotension based on the mean blood pressure (MBP) criteria. MBP of ClearSight System has a clinically acceptable agreement in precision compared to values obtained through invasive arterial pressure monitoring.

In conclusion, ClearSight System does not require invasive tech-

niques. This enables rapid and continuous monitoring of arterial pressure and waveforms without increasing the risk of complications. Furthermore, as shown in ESRD patients of this case study, monitoring of CI, SVV, and arterial pressure and waveforms under circumstances limiting the invasive placement of the arterial catheter is clinically valuable. Therefore, ClearSight System may be a useful monitoring method that can replace invasive monitoring in certain clinical situations.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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