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Resuscitation Guided by Cardiac Output using Transesophageal Echocardiography in Kidney Transplantation: Case Report

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ABSTRACT

Introduction: During kidney transplant, monitoring fluid administration is essential to ensure graft function. Transesophageal echocardiography measures the impact of fluids/medications on real time at myocardium.

Case Report: A 28-year-old female patient who underwent a kidney transplant with cardiac output resuscitation by transesophageal echocardiography: Initially, the patient presented a hypovolemic profile that responded to crystalloid infusion. By monitoring the cardiac output, fluid accumulation syndrome is avoided, leading to a distributive profile where the state of dynamic overload is physiologically de-escalated after reperfusion.

Discusion: Cardiac output-guided resuscitation using transesophageal echocardiography ensures tissue perfusion without fluid accumulation in kidney transplant surgery.

KEYWORDS: End Diastolic Volume (EDV), End Systolic Volume (ESV), Inferior Vena Cava Diameter (IVCD), Left Ventricle Ejection Fraction (LVEF), Stroke Volume (SV), Tricuspid Regurgitation (TR), Ventricular-Arterial Coupling (VAC)

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I. INTRODUCTION

Accurate assessment of hemodynamic status is essential for optimal fluid management in critically ill patients. Optimizing intravascular volume can improve tissue perfusion and therefore morbidity and mortality associated with various medical conditions. Transesophageal echocardiography allows a direct and detailed view of cardiac anatomy and function, making it an invaluable tool for evaluating hemodynamic status and guiding fluid management. By providing real-time images of the heart and adjacent structures from a close-up position, TEE allows accurate assessment of ventricular function, filling capacity, and pressure in the cardiac chambers. Written consent was obtained from the patient for the publication of this clinical case as well as approval and exemption from the consent requirement of the Research Ethics Committee.

2. CASE DESCRIPTION

28-year-old female patient (64 kg, 1.65 m) with a history of undetermined chronic kidney disease without comorbidities and with renal function replacement treatment through intermittent hemodialysis (3 times a week); 24 hours before surgery, hemodialysis was performed with 3500 ml UF. The preoperative cardiovascular evaluation included a

transthoracic echocardiogram with LVEF of 56% and adequate left cavities filling with jugular regurgitation of 1 cm/s, mild due to tricuspid insufficiency with right diastolic dysfunction type I with E/e 14 without left diastolic dysfunction E/A 0.8.

Anesthetic Procedure

Through a standardized anesthetic procedure at the Hospital Juarez of Mexico, balanced general anesthesia was administered with IV Fentanyl at a dose of 2 mcg/kg, Propofol at 2 mg/kg and Rocuronium at 0.60 mg/kg with a latency of 4 minutes and intermittent manual positive pressure ventilation with FIO2. 100%; Atraumatic laryngoscopy was performed with a 7.5 DI endotracheal tube + 4ml of pneumotamponade and <10% leak. It is connected to an anesthetic circuit with mechanical ventilation in PCV-VG mode, VTE 6-8 ml/kg, RR 10-17 rpm, I:E 1:2.5, PEEP 6-8 according to PEEP/ARDSnet. For anesthetic maintenance, Desflurane 0.8-1.2 MAC with Sedline 30-50 PSI is used. The right jugular vein was cannulated with a 7FR central catheter and a 20G right radial arterial line.

At induction, three boluses of 100 ml/hr are administered to dilute medications (antibiotic therapy, steroids, and antihistamines). The immunosuppressive medication is administered diluted in SF0.9% 250 ml for 6 hours at a rate of 41.6 ml/hr. An infusion of Sol Hartman at 10 ml/kg was administered for fluid maintenance and boluses of Sol Hartman at 250 ml were administered to maintain a normalized Cardiac Output of 6-8 Lt/min. In case of hypotension, a bolus of ephedrine 5 mg IV is administered every 3-5 minutes until the episode resolves.

During kidney transplant, Type I Monitoring (GE Monitor) is performed: Systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), heart rate (HR), pulse variation index (PVI); Type II monitoring (Hemosphere/Edwards): Central venous pressure (CVP), mean systemic filling pressure (MSFP), systemic vascular resistance (SVR), stroke volume (SV), cardiac output (CO), stroke volume variability (SVV); Type III monitoring with transesophageal echocardiography (TEE/TE7): Cardiac Output (CO), tricuspid regurgitation jet (TR), inferior vena cava diameter (IVCD), estimated right atrial pressure (RAP), estimated arterial pressure pulmonary volume (PSAP), end-systolic volume (ESV), end-diastolic volume (EDV) and ejection fraction (LVEF).

Echocardiographic Monitoring (TEE)

The transesophageal probe is introduced orally in a neutral position to the mid-esophageal plane where with a bicaval view (115°) with visibility of the inferior vena cava. In a four-chamber plane (0°) by means of the Simpson method and continuous integral of the left ventricular outflow tract (LVOT), images and 30-second video were obtained for end-systolic (ESV) and end-diastolic (EDV) measurements in each period: 1) Beginning Anesthesia, 2) Warm Ischemia (donor), 3) Cold Ischemia, 4) Renal Vein Anastomosis, 5) Renal Artery Anastomosis, 6) Before Reperfusion (1min), 7) At Reperfusion(1min), 8) to Reperfusion(5min), 9) to Reperfusion(10min), 10) End of Anesthesia (aponeurosis closure). All measurements were performed by trained personnel with a master's degree in Transesophageal Echocardiography from the Spanish Society of Clinical Echocardiography.

Beginning of Anesthesia

At the beginning of surgery, SBP 150mmHg, DBP 87mmHg, TAM 108mmHg, HR 83beats/minute, CVP 6mmHg, MSFP 11.7mmHg, SV 39ml/min, SVR 2521dynas/cm3, CP 0.89J/min, EH 0.46, VVS 8 were recorded. %, PVI 11%, VPS 13%. Regarding the TEE variables, TR was found to be 1.0cm/sec, IVCD 1.0cm, RAP 5.0mmHg, PSAP 9.0mmHg, ESV 24l/min, EDV 63ml/min and LVEF 61.7%; Arterial Elastance (AE) 3.46, ventricular elastance (VE) 5.57 and Ventriculo-Arterial Coupling (VAC) 0.62. The cardiac output by Hemosphere was 3.4Lt/min while that by TEE was 3.2Lt/min.

Before Reperfusion in Kidney Transplant

At reperfusion there was a SBP of 133mm Hg, DBP 83mm Hg, MAP 100mmHg, HR 80beats/minute, CVP 16mmHg, MSFP 21.5mmHg, SV 113ml/min, SVR 881dynas/cm3, CP 1.59J/min, EH 0.26, VVS 2%, PVI 2% and VPS 5%. Regarding the TEE variables, TR was found to be 4.0cm/sec, IVCD 3.0cm, RAP 15mmHg, PSAP 79mmHg, ESV 80ml/min, EDV 175ml/min and LVEF 54.2%. AE 1.26, VE 1.49, VAC 0.84. The cardiac output by Hemosphere was 7.12Lt/min while that by TEE was 7.18Lt/min (figure 1).

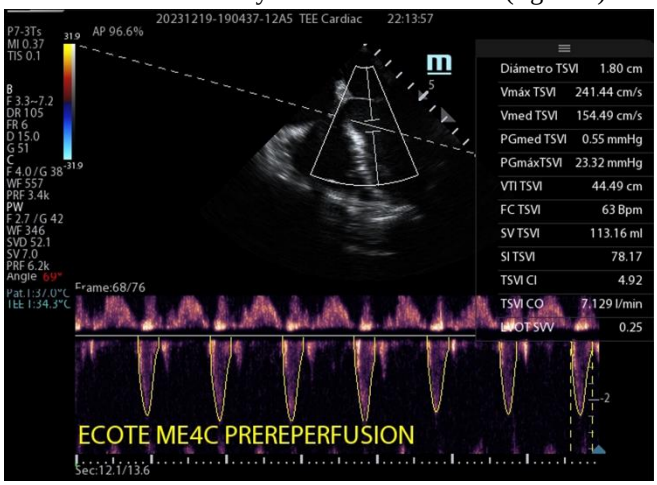


Figure 1. Transesophageal echocardiographic values obtained at reperfusion in kidney transplantation.

After Reperfusion in Kidney Transplant

After reperfusion she presented SBP 120mmHg, DBP 82mmHg, MAP 95mmHg, HR 65beats/minute, CVP 12mmHg, MSFP 17.4 mmHg, SV 111ml/min, SVR 938dynas/cm3, CP 1.48J/min, EH 0.31, SVV 5%, PVI 4%, VPS 8%. Regarding the TEE variables, TR was found to be 3.0 cm/sec, IVCD 1.8 cm, RAP 9.0 mmHg, PSAP 45mmHg, ESV 66ml/min, EDV 147ml/min, LVEF 55%. AE 1.33, VE

1.63, VAC 0.82. The cardiac output by Hemosphere was 7.08Lt/min while by TEE it was 7.05Lt/min (figure 2-3).

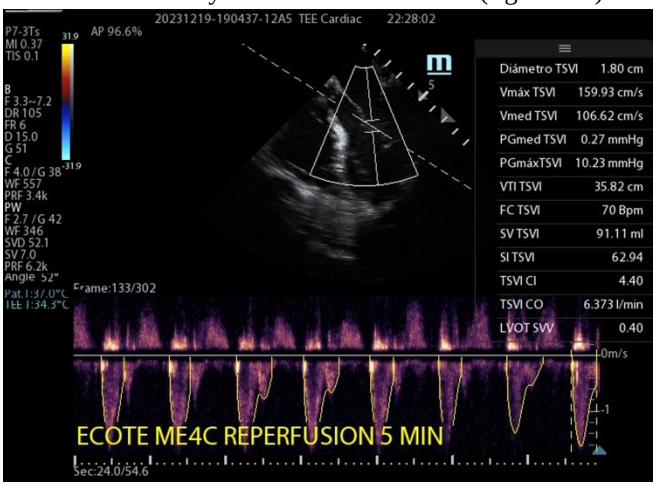


Figure 2. Transesophageal echocardiographic values obtained 5 min after reperfusion in kidney transplantation.

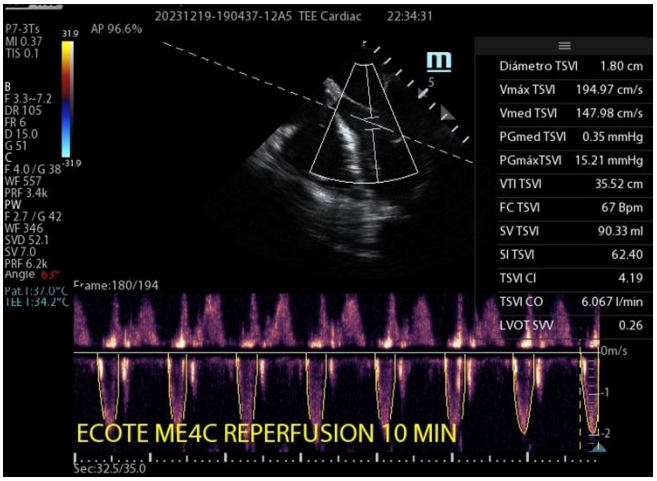


Figure 3. Transesophageal echocardiographic values obtained 10 min after reperfusion in kidney transplantation.

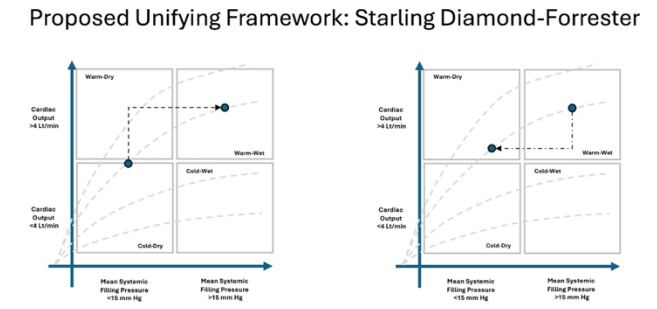
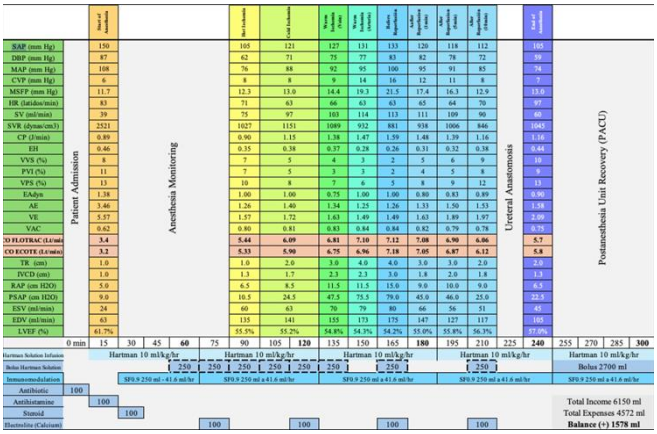


Figure 4. Combination of the Frank-Starling relationship with Diamond-Forrester profiles. In a contemporary ultrasound-based interpretation, the venous excess according to mean systemic filling pressure (MSFP <15 mm Hg) dichotomizes cardiac filling on the x-axis and cardiac output (CO <4 Lt/min), dichotomizes the filling volume on the y-axis. On the left is shown the escalation period of the patient undergoing kidney transplant from the beginning of anesthesia until before reperfusion (transient dynamic overload); On the right is shown the period of escalation of fluid accumulation in the patient undergoing kidney transplant from before reperfusion to the end of anesthesia.

Table 1. Hemodynamic and echocardiographic values during different stages of kidney transplantation.

End of Anesthesia



At the end of the procedure, SBP 105 mmHg, DBP 59 mmHg, MAP 74 mmHg, HR 97 beats/minute, CVP 7mmHg, MSFP 13mmHg, SV 60 ml/min, SVR 1045 dynas/cm3, CP 1.16J/min, EH 0.44 were obtained. , VVS 10%, PVI 9%, VPS 13%. Regarding the TEE variables, TR 2.0cm/sec, IVCD 1.3cm, RAP 6.5mmHg, PSAP 22.5mmHg, ESV 45ml/min, EDV 105ml/min and LVEF 57% were found. AE 1.58, VE 2.09, VAC 0.75. The cardiac output by Hemosphere was 5.7Lt/min while that by TEE was 5.8Lt/min.

Total fluid intake was 6150ml: 8 boluses of Sol Hartman 250 ml (2000ml), 7 boluses of SF0.9% 100 ml (700ml), Sol Hartman perfusion at 10ml/kg/hr 3200ml) and immunosuppressant perfusion SF0 were administered. .9% (250ml). The expenses were 4572ml for a total balance (+) 1578ml. Only 3 boluses of 5 mg IV ephedrine were required to maintain normotension.

Upon the patient's discharge from the operating room, the patient had an expiratory inferior vena cava diameter of 1.8 cm with a colpsability of 38.8%; VEXUS Total Score of 1 points was obtained with a Suprahepatic Vein pattern S=D. (increase in RAP); Portal Vein pulsatility of 30% and Renal Vein of the graft with continuous monophasic doppler wave. LUSS Score with all the PLAPS with “A” Pattern.

The presurgical proBNP clearance was 4250 ng/L while the postsurgical value of 1058 ng/L. The pre-surgical serum creatinine clearance was 11.7 mg/dL while the post-surgical value on the first day was 2.55 mg/dL, second day was 1.38 mg/dL and at discharge 0.98 mg/dL. The patient was discharged without renal function replacement treatment 5 days after the surgical procedure.

3. DISCUSION

The ability to predict patient's response to fluid administration is essential to avoid volume overload, especially in patients undergoing renal transplantation (RRCT). In the distributive hemodynamic profile, patients have elevated CO, decreased SVR with elevated intracardiac pressures (CVP/PSAP), which is why CRRT is essential for maintaining normalized CO (6-8Lt/min). After performing hemodialysis, the decrease in intravascular volume also decreases intracardiac pressures and CO, changing the hemodynamic profile from distributive to hypovolemic.

The patient initial presents an initial hypovolemic profile that responds and tolerate adequately to crystalloid infusion increasing stroke volume and cardiac output. As cardiac output increases progressively, the patient recovers the distributive profile leading to a state of tolerable dynamic fluid accumulation at the independent portion of the Starling curve.

Upon reperfusion the kidney graft extracts intravascular volume (approximately 0.5-1Lt/min of cardiac output) which produce a physiological state of stabilization and evacuation in which the fluid conservative management produces a de-escalation and improvement of ventriculo-arterial coupling ensuring adequate tissue perfusion and urine production.

The right ventricle can adapt to overhydration with a progressive increase in cardiac power (systolic function); However, increasing the volume also increases the pressure, revealing a transient hypervolemia (PSAP >40mmHg) with slight tricuspid insufficiency (TR >2) that progressively decrease myocardial efficiency (diastolic function) until reperfusion. At the reperfusion the physiological de-escalation maintains and improves the cardiac performance and therefore the perfusion of the graft without compromising organ function (figure 4).

It is essential to understand the distributive profile and the dynamic overload (fluid accumulation) presented by patients undergoing kidney transplantation. This includes the need to identify hemodynamic markers of intravascular volume status such as the values from transesophageal echocardiography and optimal rates of fluid infusion during the surgery procedure.

In the consensus documents there is low-quality evidence regarding the high rate of fluid or volume infusion with the objective of increasing intracardiac pressures (CVP). There are currently no studies regarding the use of cardiac output as a resuscitation objective in patients undergoing kidney transplantation.

ABBREVIATIONS

End Diastolic Volume (EDV); End Systolic Volume (ESV); Inferior Vena Cava Diameter (IVCD); Left Ventricle Ejection Fraction (LVEF); Mean Systemic Filling Pressure (MSFP); Myocardial Efficiency (EH); Systemic Vascular Resistance (SVR); Stroke Volume (SV); Tricuspid Regurgitation (TR); Ventricular-Arterial Coupling (VAC)

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