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Decongestion Guided Through Doppler Ultrasound of the Supra-Hepatic Vein by Transesophageal Echocardiography in a Kidney Transplant Patient: Clinical Case

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ABSTRACT

INTRODUCTION: The hepatic vein decongestion is a crucial aspect in the management of various liver and cardiac conditions, where excessive blond accumulation in the liver can lead to serious complications such as portal hypertension and liver failure. The hepatic vein, responsible for blood draining from the liver to the general circulation, can be affected by a pathologies variety that alter its functionality and consequently, the venous return.

CASE REPORT <u>Scenario</u>: A 32-year-old female patient (56 kg, 1.55 m) with a chronic kidney disease history in pre-dialysis without renal function replacement treatment underwent an anticipated related living donor kidney transplant. The procedure is performed under balanced general anesthesia according to the standards of the Hospital Juarez de México with type III monitoring with transesophageal echocardiography with Mindray TE7 Ultrasound, Edwards Hemosphere and GE Vital Signs Monitor.

During kidney transplantation, type I monitoring (GE monitor) is performed: Systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), heart rate (HR); 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/MindrayTE7): End-systolic volume (ESV), end-diastolic volume (EDV) and ejection fraction (LVEF) and supra-hepatic vein doppler velocity from baseline on “S” and “D” wave. Measurements were made during all different kidney transplantation stages.

Before Reperfusion in Kidney Transplantation: SBP 133mmHg, DBP 76mmHg, TAM 95mmHg, HR 69bpm, CVP15mmHg, MSFP20.04mmHg, SV89ml/min, CO6.14lt/min, SVR 1041dynas/cm3, SVV11%, CP1.29J/min, EH0.25, EDV149ml/min, ESV60l/min, LVEF59.7%, AE1.34, VE2.0, AoV0.67. When measuring the values by Doppler ultrasound of the “S” and “D” waves, they were 37.22cm/s and 41.44cm/s, so the S/D Index is 0.9

Reperfusion (1st minute): SBP124mmHg, TAD75mmHg, MAP91mmHg, HR67bpm, CVP13mmHg, MSFP17.76mmHg, SV81ml/min, CO5.43lt/min, SVR1154dynas/cm3), SVV12%, CP1.1J/min, EH0.27, EDV136ml. /min, ESV55ml/min, LVEF59.6%, AE1.38, VE2.03,

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AoV0.68. When measuring the values by Doppler ultrasound of the “S” and “D” waves were 39.94cm/s and 32.14cm/s, so the S/D index is 1.24.

DISCUSSION: When the patient presents dynamic fluid overload (before reperfusion), the “S” wave decreases its amplitude/velocity and thus the right ventricle capacity to manage hepatic venous flow during systole. In this case “D” wave, shows a low velocity flow during diastole, so in congestion due to the increase in portal pressure the retrograde velocity increases and therefore the S<D pattern, and S/D index is less than 1.

CONCLUSION: Hepatic vein doppler is a valuable tool in the management of fluid de-escalation in kidney transplant patients.

KEYWORDS: Hepatic Vein Doppler, Transesophageal Echocardiography, Decongestion, Fluid Overload, Kidney Transplantation

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I. INTRODUCTION

Hepatic vein decongestion is a crucial aspect in the management of various liver and cardiac conditions, where excessive blood accumulation in the liver can lead to serious complications such as portal hypertension and liver failure. The hepatic vein, responsible for draining blood from the liver to the general circulation, can be affected by a pathologies variety that alter its functionality and consequently, the venous return.

The integration of transesophageal echocardiography with doppler mode adds an additional level of precision in the assessment of the hepatic vein. This approach, by placing the ultrasound probe in a position close to the heart and liver, improves the visualization and quality of the data obtained, allowing a more complete liver decongestion evaluation.

The evaluation and hepatic congestion management in this context requires a multidisciplinary approach and the use of advanced diagnostic tools. Continuous monitoring using imaging techniques, such as Doppler Ultrasound, is essential to assess hepatic blood flow and detect early congestion signs. Thus, a detailed understanding and proactive management of hepatic decongestion is crucial to optimize the well-being of the transplant patient, improve kidney graft function, and minimize the risk of liver and renal complications.

II. CASE REPORT: SCENARIO

A 32-year-old female patient (56 kg, 1.55 m) with a chronic kidney disease history in pre-dialysis without renal function replacement treatment underwent an anticipated related living donor kidney transplant. The procedure is performed under balanced general anesthesia according to the standards of the Hospital Juarez de México with type III monitoring with transesophageal echocardiography with Mindray TE7 Ultrasound, Edwards Hemosphere and GE Vital Signs Monitor.

Anesthetic Procedure:

Through a standardized anesthetic procedure at the Juarez Hospital in 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 intermittent manual positive pressure ventilation with FIO2 100%; Atraumatic laryngoscopy was performed and endotracheal intubation with Murphy 7.5 tube and 3ml of air in ballon with 10% leak. Desflurane 0.8-1.2 MAC with Sedline 30-50 PSI is used for anesthetic maintenance with mechanical ventilation in PCV-VG mode, VTE 7ml/kg, RR 10-14 rpm, I:E 1:2.5, PEEP 6mmHg according to PEEP/Ardsnet. Right jugular vein with 7FR central catheter and left radial arterial 20G line were cannulated with seldinger technique.

At induction, 3 boluses of 100 ml SF0.9% were administered with the dilution of antibiotic therapy (Ceftriaxone 1 g IV), steroid (Methylprednisolone 500 mg IV) and antihistamine (Diphenhydramine 100 mg IV). The immunosuppressive agent (Basiliximab 20mg IV) was administered using SF0.9% 250 ml for 6 hours at a rate of 41.6 ml/hr.

Intraoperative fluids were determined as follows:

1. Sol.Hartman perfusion at 10ml/kg/hr for water maintenance.
2. Additional boluses of Sol.Hartman 250ml to maintain TAM>65 mmHg
3. If 2 additional boluses of Sol.Hartman 250ml are administered and MAP <65 mmHg persists, a bolus of Ephedrine 5mg IV is administered.
4. If 2 additional boluses of Sol.Hartman 250ml are administered and HR <40bpm persists, a bolus of Atropine 1mg IV is administered.2. Additional boluses of Hartman solution 250ml to maintain TAM>65 mmHg

During kidney transplantation, type I monitoring (GE monitor) is performed: Systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), heart rate (HR); 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/MindrayTE7): End-systolic volume (ESV), end-diastolic volume (EDV) and ejection fraction (LVEF). Measurements were made during all different stages of kidney transplantation.

Echocardiographic Monitoring (TEE Monitoring)

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 (IVT-LVOT), images and 30-second video are obtained for end-systolic (VTS) and end-diastolic (VTD) measurements. Finally, it is introduced and transgastric long axis is performed at 120-140° (To obtain the transgastric long axis, rotate the probe slightly to align the image longitudinally from the base of the heart towards the liver) it is visualized emerging from the top of the IVC. where, using the color Doppler method, it is placed over the supra-hepatic vein and the amplitude of the wave is measured from the baseline. Measurements are made in each period: 1) Beginning Anesthesia, 2) Hot Ischemia, 3) Cold Ischemia, 4) Warm Ischemia, 5) Before Reperfusion, 6) Reperfusion (1minute), 7) Reperfusión (5minute), 8) Reperfusion (10minute) and 9) Final Anesthesia. All measurements were performed by trained personnel with a Master's degree in Transesophageal Echocardiography from the Spanish Society of Clinical Echocardiography.

III. RESULTS

Before Reperfusion: SBP 133mmHg, DBP 76mmHg, TAM 95mmHg, HR 69bpm, CVP15mmHg, MSFP20.04mmHg, SV89ml/min, CO6.14lt/min, SVR 1041dynas/cm3, SVV11%, CP1.29J/min, EH0.25, EDV149ml/min, ESV60l/min, LVEF59.7%, AE1.34, VE2.0, AoV0.67. When measuring the values by Doppler ultrasound of the “S” and “D” waves, they were 37.22cm/s and 41.44cm/s, so the S/D Index is 0.9 (Table 1).

Reperfusion (1st minute): SBP124mmHg, TAD75mmHg, MAP91mmHg, HR67bpm, CVP13mmHg, MSFP17.76mmHg, SV81ml/min, CO5.43lt/min, SVR1154dynas/cm3), SVV12%, CP1.1J/min, EH0.27, EDV136ml. /min, ESV55ml/min, LVEF59.6%, AE1.38, VE2.03, AoV0.68. When measuring the values by Doppler ultrasound of the “S” and “D” waves were 39.94cm/s and 32.14cm/s, so the S/D index is 1.24 (figure 1).

Reperfusion (5th minute): SBP118mmHg, DBP76mmHg, MAP90mmHg, HR65bpm, CVP10mmHg, MSFP14.64mmHg, SV74ml/min, CO4.81lt/min, SVR1329dynas/cm3, SVV15%, CP0.96J/min, EH0.32, EDV127ml /min, ESV53ml/min, LVEF 58.3%, AE1.44, VE2.0, AoV 0.72. When measuring the values by Doppler ultrasound of the “S” and “D” waves, they were 44.32cm/s and 35.55cm/s, so the S/D Index is 1.25 (figure 2).

Reperfusion (10th minute): SBP110mmHg, DBP70mmHg, MAP83mmHg, HR63bpm, CVP9mmHg, MSFP13.16mmHg, SV63ml/min, CO3.97lt/min, SVR1497dynas/cm3, SVV16%, CP0.73J/min, EH0.32, EDV113ml/ min, ESV50ml/min, LVEF 55.8%, AE1.57, VE1.98, AoV0.79. When measuring the values by Doppler ultrasound of the “S” and “D” waves, they were 45.34cm/s and 33.2cm/s, so the S/D Index is 1.37 (figure 3).

Table 1. Hemodynamic and echocardiographic values obtained during different kidney transplantation phases.

	Anesthesia Beginning	**Hot Ischemia**	**Cold Ischemia**	**Warm Ischemia**	**Before Reperfusion**	**Reperfusion (1minute)**	**Reperfusion (5minute)**	**Reperfusion (10minute)**	**Anesthesia Final**
SBP (mmHg)	147	108	119	129	133	124	118	110	106
DBP (mmHg)	89	67	71	73	76	75	76	70	65
MAP (mmHg)	108	81	87	92	95	91	90	83	79
FR (beats/min)	88	59	61	64	69	67	65	63	61
CVP (mmHg)	4	7	8	10	15	13	10	9	7
MSFP (mmHg)	**8.89**	**10.81**	**12.09**	**14.65**	**20.04**	**17.76**	**14.64**	**13.16**	**10.91**
SV (ml/min)	27	49	51	72	89	81	74	63	57
CO (lt/min)	**2.38**	**2.89**	**3.11**	**4.61**	**6.14**	**5.43**	**4.81**	**3.97**	**3.48**
SVR /dynas/cm3)	3509	2036	2029	1416	1041	1154	1329	1497	1647
SVV (%)	20	16	15	13	11	12	15	16	17
CP (J/min)	0.57	0.52	0.60	0.94	1.29	1.10	0.96	0.73	0.61
EH	0.55	0.35	0.34	0.32	0.25	0.27	0.32	0.32	0.36
EDV (ml/miin)	67	86	95	131	149	136	127	113	105
ESV (ml/min)	32	41	44	59	60	55	53	50	48
LVEF (%)	52.2%	52.3%	53.7%	55.0%	59.7%	59.6%	58.3%	55.8%	54.3%
AE	4.90	1.98	2.10	1.61	1.34	1.38	1.44	1.57	1.67

VE	4.13	2.37	2.43	1.97	2.00	2.03	2.00	1.98	1.99
AoV	1.19	0.84	0.86	0.82	0.67	0.68	0.72	0.79	0.84
Hartman Sol (bolus ml)	250	500.00	250.00	250.00	500.00	500.00	250.00	-	-
Efedrine (bolus mg)	-	5	5	5	-	-	-	-	-

End of Anesthesia: The hemodynamic and echocardiographic values were: SBP106mmHg, DBP65mmHg, MAP79mmHg, HR79bpm, CVP7mmHg, MSFP10.91mmHg, SV57ml/min, CO3.48lt/min, SVR1674dynas/cm3), SVV17%, CP0.61J/min, EH0.36, EDV105ml /min, ESV48ml/min, LVEF54.3%, AE1.67, VE1.99, AoV0.84. When measuring the values by Doppler ultrasound of the "S" and "D" waves, they were 46.12cm/s and 32.7cm/s, so the S/D Index is 1.41 (Table 2).

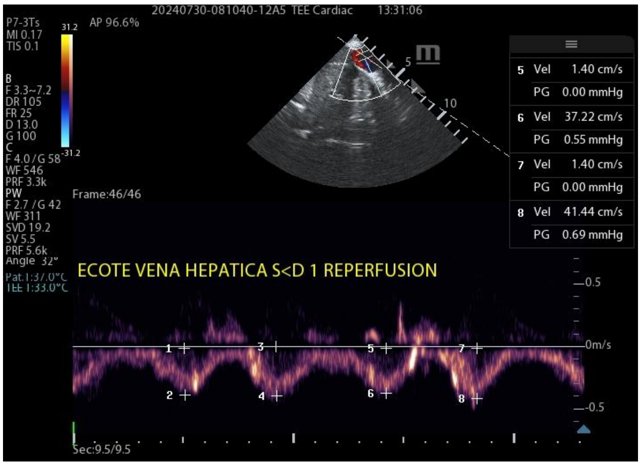

Figure 1. Hepatic Vein Doppler at reperfusion in the kidney transplant patient.

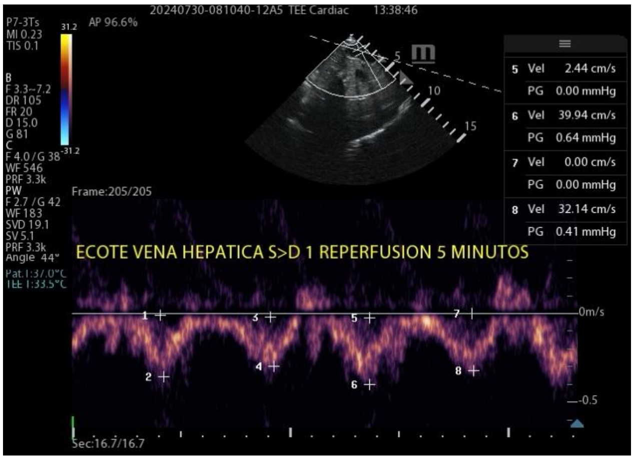

Figure 2. Hepatic Vein Doppler at 5th minute reperfusion in the kidney transplant patient.

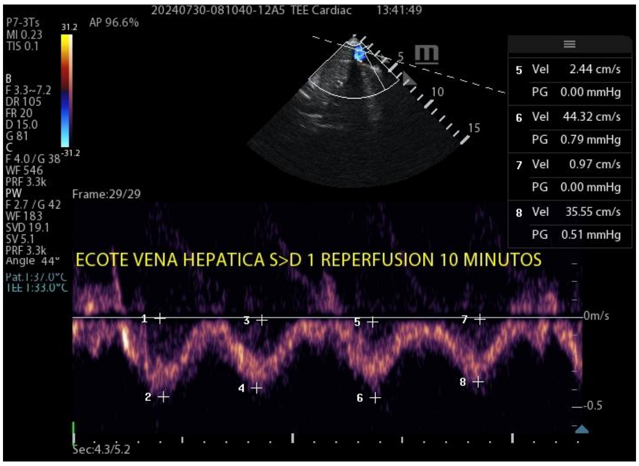

Figure 3. Hepatic Vein Doppler at 10th minute reperfusion in the kidney transplant patient.

Table 2. Echocardiographic values obtained from Supra-hepatic Vein Doppler in the "S" wave and the "D" wave during different transplant phases.

	Anesthesia Beginning	Hot Ischemia	Cold Ischemia	Warm Ischemia	Before Reperfusion	Reperfusion (1minute)	Reperfusion (5minute)	Reperfusion (10minute)	Anesthesia Final
Doppler Wave "S" (cm/s)	35.6	30.29	34.78	36.4	37.22	39.94	44.32	45.34	46.12
Doppler Wave "V" (cm/s)	27.3	28.17	33.85	35.9	41.44	32.14	35.55	33.2	32.7
S/D Index Hepatic Vein	1.30	1.08	1.03	1.01	0.90	1.24	1.25	1.37	1.41

IV. DISCUSSION

Hepatic vein doppler ultrasound is an appropriate monitoring tool in kidney transplant patients and its evaluation allows obtaining data in real time about the speed and flow direction. This approach is particularly useful in these patients since it allows the fluids de-escalation to be appropriately managed starting from the reperfusion phase. The ability to visualize flow dynamics in real time allows management strategies to be adjusted in real time, preventing circulatory overload and maintaining a hemodynamic balance that optimizes the kidney graft functioning.

Renal reperfusion is a critical step in kidney transplantation that entails a hemodynamic changes series that must be precisely addressed to guarantee the graft functionality and the hemodynamic patient stability. The gradual reduction of intravascular volume (de-escalation) due to the fluids redistribution and the expansion of the vascular bed decreases central venous pressure, mean systemic filling pressure and cardiac output, thus allowing better ventriculo-arterial coupling.

Blood flow through the hepatic vein is regulated efficiently facilitating the blood return from the liver to the inferior vena cava and subsequently to the right atrium. During systole, the “S” wave shows a higher velocity due to cardiac contraction, while the “D” wave presents a lower flow velocity since it reflects diastole during isovolumetric relaxation. When the patient presents dynamic fluid overload (before reperfusion), the “S” wave decreases its amplitude/velocity and thus the right ventricle capacity to accommodate hepatic venous flow during systole. In the case of the “D” wave, it shows a low velocity flow during diastole, so in congestion due to the increase in portal pressure the retrograde velocity increases in diastole and therefore the S>D pattern is reversed, and S/D index is less than 1.

Currently, evidence suggests an approach based on objective data and real-time hemodynamic monitoring to evaluate the patient's response to fluid infusion, promote early diuresis, and reduce the graft dysfunction incidence.

V. CONCLUSION

Hepatic vein doppler is a valuable tool in the management of fluid de-escalation in kidney transplant patients. Its ability to reveal alterations in the “S” and “D” waves provides crucial information about venous pressure and hepatic congestion allowing precise adjustments in fluid therapy.

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