ISSN: 2996-3885

Cardiology & Cardiovascular Research

Case Report

Volume-Responsiveness Guided Hemodynamic Resuscitation with Passive Leg Raise by a Swan-Ganz Catheter and Point-Of-Care Echocardiogram in a Case of Mixed Shock

Erick Josué Lázaro Montes de Oca[1*], Felipe de Jesús Montelongo[2], Alan Abdala Ruiz Ortega[1], Mauricio Rodríguez Vera[1], Luis Eduardo Segura Medina[3], Josafat Jesús Gutiérrez de la Cruz[1], Margarito Cortez Meza[1], Jonathan Galindo Ayala[1], Alfonso Armando Salazar Mendoza[1], Aurea Carmona Domínguez[3], Carlos Gustavo Ballesteros Flores[4], Roberto Flores Suárez[5], German Nava Beltrán[5], Nicolás Hernández Reyes[6]

[1]*Specialist in Emergency Medicine and Critical Care Medicine. Intensive Care Unit, HGE Las Americas. ISEM.*

[2]*Specialist in Critical Care Medicine. Chief of Service, Intensive Care Unit, HGE Las Americas. ISEM. ORCID*

[3]*Specialist in Anesthesiology and Critical Care Medicine. Intensive Care Unit, HGE Las Americas. ISEM.*

[4]*Specialsit in Critical Care Medicine. Chief of Service, Intensive Care Unit. HG Toluca. ISSSTE.*

[5]*Specialist in Internal Medicine, HGR 196. IMSS.*

[6]*Specialist in Emergency Medicine and Critical Care Medicine. Intensive Care Unit, HAE ISSSTE Tultitlan.*

Abstract

Literature does not report hemodynamic monitoring through the Swan-Ganz catheter as a dynamic variable to evaluate the response to volume. Furthermore, it does not compare it with a point-of-care echocardiogram as an alternative non-invasive monitoring method. Therefore, we present the case of a 64-year-old man admitted to the Intensive Care Unit in shock, clinically associated with sepsis with a source of infection at the pulmonary level. However, during his stay in the Unit, invasive monitoring was performed with a thermodilution catheter in the pulmonary artery, as well as an echocardiogram monitoring which showed the presence of severe myocardial dysfunction in a hyperdynamic state. Resuscitation was initiated by measuring cardiac output by thermodilution and ultrasonography. This dynamic helped to assess the volume responsiveness by raising the leg passively, which showed that the patient was non-responsive. Management was focused on serial monitoring and use of an inotropic drug, presenting a marked clinical improvement until the resolution of the pathological state and the subsequent release from intensive care due to the patient's condition improves.

Keywords

Volume response, Passive leg raise test, Swan-Ganz catheter, Point-of-care echocardiogram.

Corresponding Author Information

Dr. Erick Josué Lázaro Montes de Oca, Specialist in Emergency Medicine and Critical Care Medicine. Intensive Care Unit, HGE Las Americas. ISEM, Mexico; E-mail: erilaz_jos@hotmail.com.

Received: November 01, 2023; **Accepted:** December 11, 2023; **Published:** December 16, 2023

Citation: Lázaro Montes de Oca EJ, Montelongo FJ, Ruiz AAO, Rodríguez M Vera, Segura Luis EM, et al. Volume-Responsiveness Guided Hemodynamic Resuscitation with Passive Leg Raise by a Swan-Ganz Catheter and Point-Of-Care Echocardiogram in a Case of Mixed Shock. Cardiol Cardiovasc Res. 2023;1(1):1-4.

Introduction

Hemodynamic monitoring and diagnosis are distinct entities with common characteristics. Monitoring tools such as cardiac output (CO) monitors can aid in making a diagnosis, and it is possible to use the tools or media repeatedly to monitor cardiovascular function and response to treatment.

The use of a dynamic circulation assessment is a fundamental component of hemodynamic monitoring, as demonstrated by Max Harry Weil in 1965 when he described the effect of fluid loading on the state of shock: "the effect of fluid replacement on the clinical status of the patient in shock is measured by changes in targets in the circulation such as blood pressure, alertness, urine flow, peripheral vascular filling, and skin appearance and texture." However, the limitations of clinical and static values, such as central venous pressure of hemodynamic variables, remain questioned. In recent decades, the physiology accompanying dynamic assessments has been established. As a result, it provides a different approach (dynamic approach), which aims to predict the response to fluid overload precisely without unnecessary fluid administration [1]. This dynamic approach is based on the assessment of "preload dependence." This can be done by observing respiratory cycle-dependent variations in intravascular pressures, vascular diameters, and systolic volume or their surrogates and by directly observing the effect of a volume change induced by the passive leg raise test [2].

Hemodynamic monitoring and resuscitation have been proposed with a Swan-Ganz (SG) catheter reference standard. Although it is a static test or variable of volume responsiveness, clinical practices commonly use it in intensive care units [3]. It is proposed as dynamic by adding the passive leg raise test to evaluate volume-responsive or non-volume-responsive patients, with a cutoff point of 10% [4]. In addition, transthoracic echocardiogram (TTE), traditionally considered solely as a diagnostic tool, has become relevant as a functional tool when monitoring critically ill patients or points of care over time since its introduction. The barriers to its use are disappearing due to greater equipment availability following a decrease in costs, which has led to increasing the number of trained operators. However, the operator-dependent factor continues to be a limitation [5].

Clinical Case

The patient is a 64-year-old male with a history of type 2 diabetes mellitus with ten years of evolution, currently treated with metformin and systemic arterial hypertension treated with enalapril. He also has a history of community-acquired pneumonia one month before hospitalization. His current condition began three days before his admission. The patient presented dyspnea on average effort, with a progressive exacerbation until he presented dyspnea on short effort, lower extremities edema up to below the knee, and oxygen saturation of 60% by pulse oximetry. Hence, he was admitted to the emergency department of the General Hospital of Ecatepec Las Américas of the State of Mexico Health Institute (Instituto de Salud del Estado de México). His vital signs were blood pressure of 160/90 mmHg, heart rate of 101 beats per minute, and respiratory rate of 30 breaths per minute, at the initial management with oxygen supplementation by mask with a reservoir at 10 liters per minute. However, he had persistent respiratory distress. As consequence, he was transferred to the Internal Medicine Department, where he presented ventilatory deterioration with a decrease in the PaO_2/FiO_2 ratio of 117 and hemodynamic deterioration with arterial hypotension of 60/40 mmHg with the administration of the vasopressor norepinephrine. Subsequently, he was admitted to the Intensive Care Unit with a blood pressure of 109/76 mmHg, mean arterial pressure of 84 mmHg, a heart rate of 107 beats per minute, a respiratory rate of 24 per minute, and a temperature of 37.2 degrees Celsius, as well as an electrocardiogram with premature ventricular complexes and morphology of right bundle branch block of the bundle of His. Clinically, his diagnosis was a mottling score of three points and a progressive increase of vasopressor norepinephrine, which then, required a vasopressin administration to maintain a mean perfusion pressure of 75 mmHg.

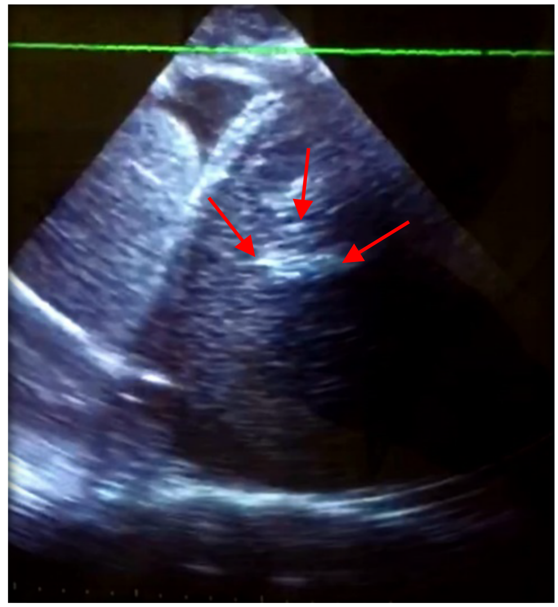


Figure 1: Red arrows show the dynamic "C" pattern on the basal right hemithorax.

Pulmonary ultrasonography was performed. It documented a dynamic C pattern in the right basal region (Figure 1), suggestive of consolidation due to lobar pneumonia. As a result, he received antibiotic treatment with meropenem. Moreover, with hemodynamic instability, this pattern was established as a probable vasodilated septic shock but a point-of-care TTE where severe observed global hypokinesia was qualitatively observed at the level of the left ventricle was also performed. This is the ultrasound video. Here the link: http://youtu.be/RkPAT9K_S3A. The outflow tract (LVOT) was measured at the aortic annulus level with a diameter of 1.8 cm and a velocity time integral of 14.2 cm/sec; these amounts were used to calculate a CO by Bernoulli's Equation [6] of 3.9 L per minute and a cardiac index (CI) of 2.1 L/SC. Shock was classified as a mixed shock with cardiac depression and placement of a thermodilution catheter in the pulmonary artery was ordered for a complete hemodynamic assessment. A hemostasis introducer was installed, an ultrasound guided SG [7] was placed (Figure 2), and a chest X-ray was requested to corroborate its correct position (Figure 2). The patient was found to have a pulmonary artery occluded pressure of 40 mmHg, an indexed CO of 2.1 L/SC, a systolic volume of 32 mL, and a left ventricular stroke work index (LVSWI) of 43 gr*m/m^2 and right VSWI of 10 gr*m/m^2, as well as an indexed oxygen consumption of 131 mL/min and an indexed availability of 802 mL/min, establishing a hemodynamic pattern of septic shock with moderate to severe cardiac depression that places him in group II of the Frank-Starling curve within the hyperdynamic phase of microcirculation. In addition, he had pulmonary artery hypertension with a systolic pressure of 44 mmHg.

Serial measurements of CG were performed simultaneously by thermodilution (Table 1) and by TTE (Table 2). They assessed

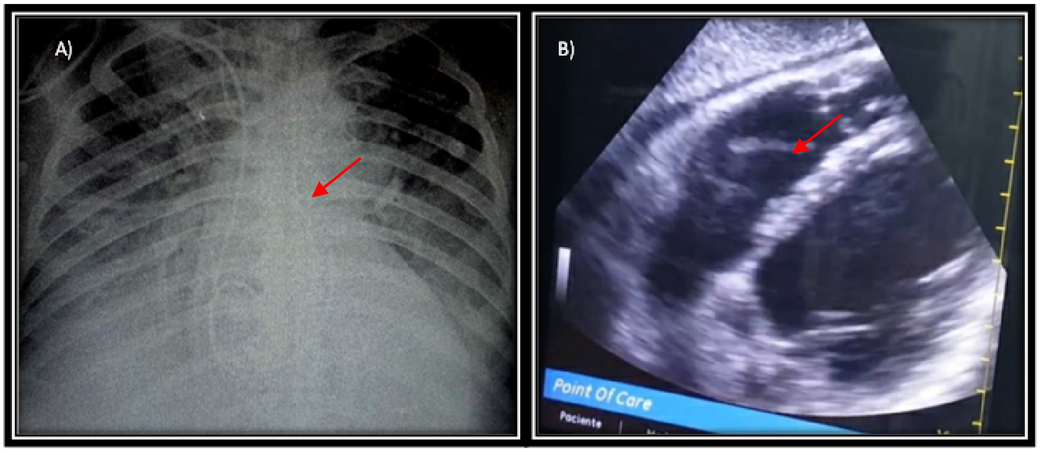


Figure 2: A. Portable chest x-ray, a Swan-Ganz catheter in the pulmonary artery is shown, "red arrow." B. Subxiphoid ultrasound, where a Swan-Ganz catheter in the pulmonary artery can be seen, "red arrow."

	Day 1		Day 2				Day 3	
Time	13:28	19:00	00:00	06:00	12:50	19:00	05:10	14:16
CS	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
CO (4-6 L)	3.43	3.7	5.8	5.45	3.7	3.8	5.18	5.18
CF (60-200 beats per minute)	106	104	98	88	80	101	79	111
SBP	116	123	106	102	111	113	144	132
DBP	82	82	68	66	69	64	69	82
MAP	93	96	81	78	89	80	94	99
sPAP (15-30 mmHg)	44	47	40	32	25	55	18	23
dPAP (5-23 mmHg)	12	8	9	4	6	18	3	18
mPAP (10-18 mmHg)	23	27	21	15	13	34	10	19
PCWP (4-12 mmHg)	40	36	33	28	22	31	20	18
IPVWP (0-8 mmHg)	7	6	9	3	3	3	8	8
SV (60-70 mL)	32.4	36.3	59.4	61.9	46.8	37.9	57.7	46.7
SVR (1000-1500 dynes)	2005	1883	989	1100	1741	1608	1592	1405
PVR (100-250 dynes)	396	275	165	191	195	163	185	150
iSVR (1800-2600 dynes)	3248	3050	1602	1783	2821	2604	2579	2276
CI (2.5-3.5 L)	2.1	2.3	3.5	3.6	2.3	2.3	2.6	3.2
LVSWI (50-62 g*m/m2)	43.39008	50.18112	69.28416	69.52608	59.97888	43.6608	78.10272	66.57552
RVSWI (7.9-9.7 g*m/m2)	10.73088	14.11344	17.96256	13.3704	8.76096	18.55584	8.3088	12.77712
DO2 (750-1200 ml/min)	210	250	289	250	210	217	210	250
VO2 (200-280 ml/min)	1300	1376	1200	885	1005	1250	820	987
IEO2 (20-30 %)	16	18	19	17	16	17	20	19
DavO2 (4-5 ml/dl)	3	2	3	4	2	3	3	4
Norepinephrine µg/kg/min	0.3	0.4	0.3	0.1	0.1	0.07	--	--
Vassopresin IU/h	0.04	0.04	0.04	0.04	0.04	0.04	--	--
Levosimendan µg/kg/min	--	0.05	0.07	0.1	0.1	0.1	--	--
Volume Responsiveness (>10%)	7%	6%	6%	6%	9%	6%	8%	6%

Table 1: Measurements of cardiac output by Swan-Ganz catheter.

	Day 1		Day 2				Day 3	
Time	13:28	19:00	00:00	06:00	12:50	19:00	05:10	14:16
CO (4-6 L)	3.9	3.6	4.3	4.2	3.6	4	4.7	4.8
CI (2.5-3.5 L)	2.4	2.2	2.7	2.6	2.5	2.3	3	3.2
VTI (>17 cm/sec)	14.2	12.3	15.8	17.1	17.4	17.3	17.8	17.6
Volume Responsiveness (>12%)	11%	6%	5%	0%	8%	5%	4%	9%

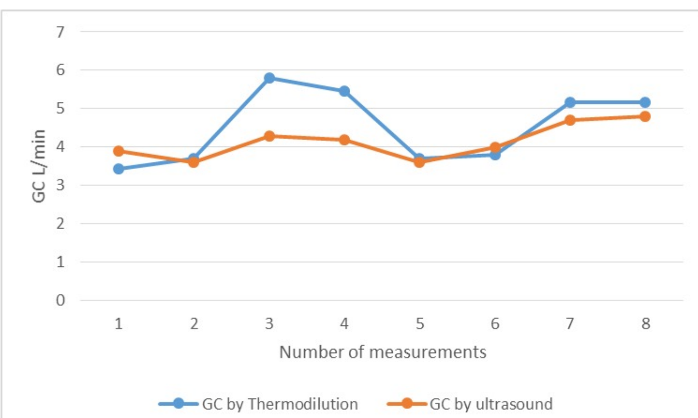
Table 2: Measurements of cardiac output by ultrasound.

volume responsiveness with passive leg raise, and it was observed that none of the measurements showed an increase in CO greater than 10% [8], which is the reason for the patient's classification as non-responder and it was decided to use Levosimendan, a continuous inotrope infusion for 48 hours. Then, the patient's hemodynamic status improved by withdrawing the vasopressor support. It also resulted in withdrawing mechanical ventilation and extubating after completing 24 hours of its withdrawal. Consequently, the discharge of the patient due to his improvement was decided.

Discussion

Employing the Frank-Starling curve, serial measurements (Table 1) showed a state of moderate to severe cardiac depression, according to an LVOT concerning the occlusion pressure of the pulmonary artery. It also showed pulmonary hypertension classified as grade III due to its mixed origin, which supports the diagnosis of cardiogenic shock probably due to cardiac depression caused by sepsis. In addition, through the measurement of the systemic vascular resistance index, the need for a vasopressor was observed to maintain it at an appropriate level. Concerning the vasodilated shock and the source of infection documented at a pulmonary level, sepsis in a hyperdynamic state was attributed as its origin. Upon establishing mixed shock in the hyperdynamic phase, an administration of inotropic Levosimendan was started with a maximum dose of up to 0.1 µg/kg/min, which showed an improvement in CO, IC, and VSWI, and a clinical improvement in macro and microhemodynamics.

When comparing the measurement of CO using thermodilution calculated by ultrasonography, a minimum variation of 300 mL on average between both measures was found which confers reliability to the non-invasive monitoring of CO calculation (Graph 1).



Graph 1: Cardiac output by thermodilution and ultrasound.

The case reported here becomes relevant now of guiding resuscitation by measuring CO through thermodilution and comparing it to the TTE point of care; however, there are no case reports describing resuscitation guided by this method.

Conclusions

This report proposes to expand further volume responsiveness monitoring using thermodilution CO measurement to guide resuscitation in critically ill patients helped by point-of-care TTE as a non-invasive option for CO measurement, as well as, performing prospective clinical studies comparing both methods.

Approval and Ethics

Confidentiality and personal data of patients are respected. They were approved with the prior informed consent signed by the relatives.

Acknowledgments

We thank the hospital and our patients without whom it would have been impossible to carry out this study.

Funding

The study was funded by the authors and the hospital.

References

1. Jabot J, Teboul JL, Richard C, et al. Passive leg raising for predicting fluid responsiveness importance of the postural change. Intensive Care Med. 2009; 35: 85-90.
2. Headley JM, Ahrens T. Narrative history of the Swan-Ganz catheter: Development, education, controversies, and clinician acumen. AACN Adv Crit Care. 2020; 31: 25-33.
3. Feissel M, Michard F, Mangin I, et al. Respiratory changes in aortic blood velocity as an indicator of fluid responsiveness in ventilated patients with septic shock. Chest. 2001; 119: 867-873.
4. Teboul JL, Cecconi M, Scheeren TWL. Is there still a place for the Swan-Ganz catheter? No. Intensive Care Med. 2018; 44: 957-958.
5. Rincón J. Ecocardiografía clínica en el paciente crítico. ZarPra. 2014; ISBN of the Book: 978677566816.
6. Ríos RCA, Meza MCA, Montelongo FJ, et al. Miocardiopatía periparto en la unidad de cuidados intensivos, reporte de caso. Rev Med Intensiva y Cuidados Crit. 2019; 13: 25-28.
7. Calzada PT, Montelongo FJ, Carmona AD, et al. Eficacia y seguridad de la técnica de colocación de catéter de arteria pulmonar guiado por ultrasonido. Med Crit. 2018; 2: 76-84.
8. Headley JM. Fiftieth anniversary of the swan-Ganz catheter: From then until now. AACN Adv Crit Care. 2020; 31: 23-24.