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RESEARCH **Open Access**

The Implementation of Passive Leg Raising in Shocked Patients: Scoping Review

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Abstract
Shock is a life-threatening condition. It is essential to perform hemodynamic support on shocked patients to restore adequate circulation. Passive leg raising (PLR) is a critical act to assess fluid responsiveness which can provide significant information about fluid needs of shocked patients. The present study aimed to identify the implementation of passive leg raising in shocked patients. The scoping review was the method used in the present study. Relevant literatures were obtained from PubMed, CINAHL and Google Scholar Search engines from 2013 to 2023. The articles were manually extracted through tabulation and the data were thematically analyzed with an exploratory descriptive approach. Nine articles were found relevant and hence were included in the present study. The findings of the 9 articles revealed that the implementation of passive leg raising in shocked patients was an early strategy in assessing fluid responsiveness and fluid administration could be decreased after 48 hours of ICU admission. The findings of the current study suggested that the implementation of PLR significantly assessed fluid responsiveness which in the end guided in conducting fluid resuscitation in shocked patients and could reduce fluid administration in shocked patients for the first 48 hours of ICU admission. Therefore, health professionals working in critical care units including critical care nurses should consider performing PLR to shocked patients.

Keywords: Passive Leg Raising, Shock, Fluid Responsiveness, Hemodynamics, Critical Care.

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1. INTRODUCTION

Shock occurs due to an imbalance between the need and supply of oxygen (Dell'Anna et al., 2019). This condition can potentially lead to multi-organ failure and death (Blumlein & Griffiths, 2022). It is crucial to perform hemodynamic support in shocked patients to restore adequate circulation. Fluid resuscitation should be commenced immediately when the shock occurs. It aims to prevent organ dysfunction and organ failure (Vincent & De Backer, 2013).

Fluid resuscitation serves as the foundation for managing patients with acute circulatory failure (Chadi, 2013). Previous studies suggest that when fluid challenge is administered to patients with unstable hemodynamics, only 50% of those patients responded to the volume expansion (Marik & Lemson, 2014). If preload unresponsiveness occurs, the increase in volume in large quantities can lead to hypervolemia which subsequently result in pulmonary and tissue edema, respiratory failure, organ dysfunction, thereby prolongs the length of inpatient care stay at ICU and dependence on mechanical ventilation (Douglas et al., 2020). To prevent interstitial fluid accumulation, it is necessary to consider the addition of inappropriate volume by assessing the fluid responsiveness (Saugel et al., 2013).

Fluid responsiveness is changes in cardiac output or stroke volume ≥10-15% (Xu et al., 2017). Increased stroke volume occurs due to the ability of the left ventricle to respond to the addition of fluid (Hasanin, 2015). An alternative strategy for predicting fluid responsiveness is by performing passive leg raising (PLR) (Rameau et al., 2017). PLR was developed to predict whether volume expansion will increase CO during resuscitation in patients with acute circulatory failure (Monnet et al., 2016).

Passive leg raising is a preload challenge that can be performed repeatedly without administering intravenous fluid (Monnet & Teboul, 2015). The procedure is an approximate amount of 150-350 ml of venous blood moving from the lower extremities translocated to the intrathoracic compartment which can increase the preload of the right ventricle and the left ventricle as a pseudo-fluid challenge (Assadi, 2017). However, the hemodynamic effect is only temporary, reversible autotransfusion in nature (Pickett et al., 2017) that it will quickly return to the initial measurement before PLR is performed (Monnet & Teboul, 2013). Therefore, an indepth review needs to be conducted to examine the implementation of passive leg raising in shocked patients to prevent further complications resulted from the addition of fluid volume. Drawing from the findings of the literature reviews, no reviews that specifically addresses the implementation of passive leg raising has been identified. This scoping review is the first to identify the implementation of passive leg raising in shocked patients. The scoping review aimed to map and identify the implementation of passive leg raising in shocked patients.

2. RESEARCH METHOD

The methodology employed in this review is a scoping review approach, following the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018). The scoping review framework consists of five main stages: finding research questions, finding relevant findings, selecting research, mapping data, compiling, summarizing and reporting findings (Peterson et al., 2017).

a. Eligibility criteria

The present study commenced with a search of literatures on the advantages of passive leg raising, research questions and the eligibility criteria of research articles under PCC (Population, Concept, Context) approach, including: Population: Patient with shock, septic or hypovolemic shock, Concept: Passive leg raise, Context: Implementation of passive leg raising. The inclusion criteria in this review are full-text articles that were accessible in English in the last 10 years since 2020 until 2023 and articles with experimental study research design, case control study, cross-sectional study, longitudinal study, case report, retrospective study and cohort study. Inaccessible and not in English full-text articles, and secondary research papers were excluded.

b. Article Searches and Selection Strategies

Article identification was carried out systematically using 2 main data bases namely CINAHL, Pubmed, and one search engine Google Scholar. The keywords used in gathering relevant articles were Shocked Patient OR septic shock OR hypovolemic shock AND passive leg raise OR passive leg raising test OR passive leg elevation AND hemodynamic.

c. Extraction and Analysis of data

The articles included in this review were extracted manually using table extraction. The results of the search were extracted in a table which outlines the author's name, year, country, research design, population and sample, intervention and research findings. The data were thematically analyzed using an exploratory descriptive approach. The research question in this review is: How is the implementation of passive leg raising in shocked patients?.

3. RESULTS AND DISCUSSION

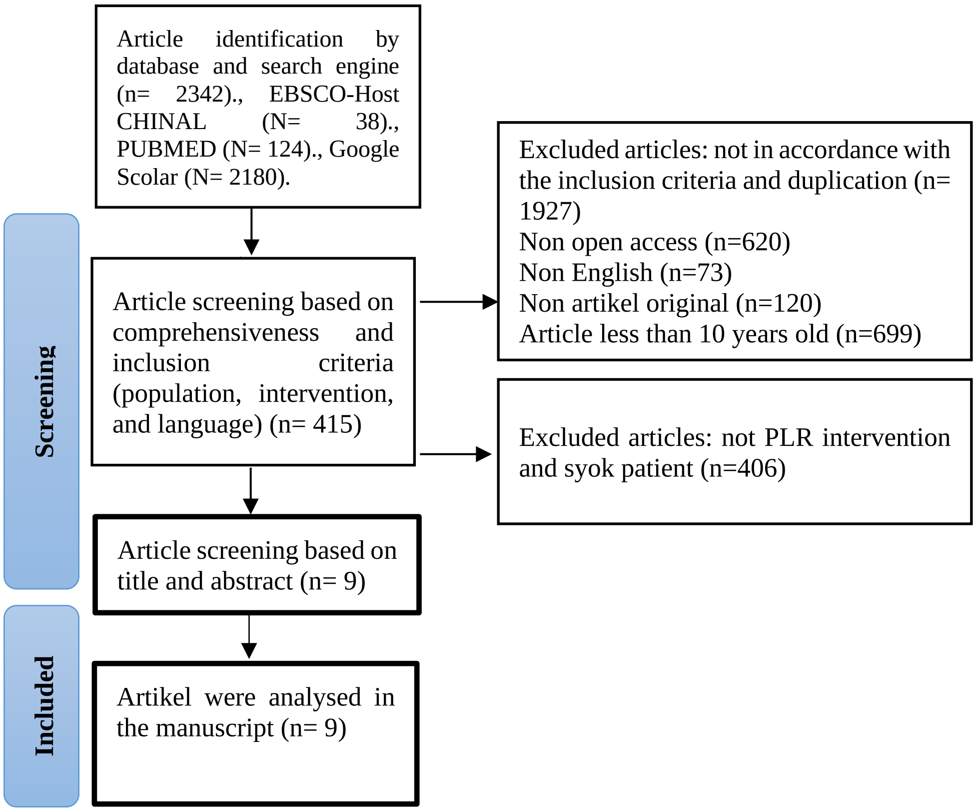

Figure 1. PRISMA Flow Diagram

Nine articles were identified to conform with the criteria set and objective of the present study, viz. to investigate the implementation of passive leg raising of which several studies have proved its effectiveness and ineffectiveness. In general, those articles addressed the implementation and the advantages of passive leg raising. According to the origin of the articles, 1 article was from the Netherlands, 1 article was from the UK, 3 articles were from the USA, 2 articles was from France, 1 article was from Singapore, and 1 article originated from Colorado. All articles under analysis consisted of 3 randomized control trials and 6 prospective observational studies published from 2013 to 2023.

Table 1. Extraction of articles

No.	Author & Country	Population	Research Method	Objective of the Study	Intervention	Result
1	(Rameau et al., 2017) Netherlands	Patients with septic shock aged > 18 years old. Sample: 21 patients	Prospective multi-step intervention study.	To test the effectiveness of PLR to reduce fluid administration.	PLR test on septic shocked patientss	There was a significant and substantial decrease in fluid administration in the first 48 hours of ICU admission and fluid balance was generally significantly reduced.
2	(Elwan et al., 2022) United Kingdom	Patients with sepsis diagnosis Sample: 39 patients	Prospective observational study.	To evaluate the accuracy of PLR in predicting fluid responsiveness	The implementation of PLR for 3 minutes and monitoring using thoracic electric bioimpedance monitor (TEB),	Better predictor PLR tests to assess fluid responsiveness.
3	(Toppen et al., 2020) Los Angeles	Shock patient, patients with persistent vasopresso, secondary hypotensive and conscious patients Sample: 79 patients	Methods: Non-interventional, prospective trial	To evaluate the safety and feasibility of PLR maneuvers.	Maneuver passive leg raising (PLR)	PLR maneuver lead to low incidence of complications in patients with unstable hemodynamics.

No.	Author & Country	Population	Research Method	Objective of the Study	Intervention	Result
4	(Jacquet-Lagrèze et al., 2019) France	Patients with acute circulatory failure Sample: 34	Prospective observational study	To assess ΔCRT-PLR in predicting increased peripheral perfusion	Conducting a PLR and VE test with Ringer Lactate of 500 mL, then performing a capillary refile time measurement	Changes in CRT during PLR predicted CRT responsiveness with good accuracy in acute circulatory failure, with a CRT decrease of 27% during PLR.
5	(Kuan et al., 2016) Singapore	Patients aged > 21 years with septic and serum lactate concentrations greater than or equal to 3.0 mmol/L. Sample: 122 patients	Randomized Controlled Trial (RCT)	To determine the use of noninvasive hemodynamic optimization combined with PLR results in lactate clearance in patients with severe sepsis and septic shock in ICU	The PLR maneuver and intravenous fluid bolus are performed using a noninvasive monitor.	Fluid resuscitation and PLR maneuvers using noninvasive cardiac output monitoring do not provide better results with regular treatment nor does it generate a significant difference in lactate clearance.
6	(Douglas et al., 2020) Colorado	Patients with sepsis or septic shock anticipate ICU admission, refractory hypotension	Randomized Controlled Trial (RCT) .	To guide the amount of intravenous fluids administered to patients with septic shock by assessing fluid responsiveness.	PLR maneuver, immediate administration of crystalloid fluid bolus, and the initiation or the increase in vasopressor titration	Resulted in lower fluid balance and reduced the risk of kidney failure and respiratory failure.

No.	Author & Country	Population	Research Method	Objective of the Study	Intervention	Result
7	(Cronhjort et al., 2017) USA	Septic shocked patients. Sample: 34 patients	Randomized Controlled Trial (RCT)	To determine fluid responsiveness with PLR can reduce fluid accumulation after 3 days of ICU admission and can reduce weight gain	Passive leg raising (PLR) test	The PLR protocol did not generate a significant reduction in weight gain in ICU for septic shocked patientss, thus PLR was not effective in reducing septic shocked patients's body weight.
8	(Mallat et al., 2022) France	Sample: 270 patients	Prospective observational study	To predict fluid responsiveness by understanding changes in pulse pressure (DPPV PLR) induced by PLR in patients with mechanical ventilation	PLR maneuver and volume expansion with 500 ml crystalloid solution administered for 15 minutes	Changes in pulse pressure variation induced by PLR could predict fluid responsiveness in mechanically ventilated patients. Relative and absolute change was a strong predictor of fluid responsiveness,
9	(Marik et al., 2013) USA	Severe septic/septic shock Sample: 34 patients	Observational study	To assess changes in stroke volume index (SVI) induced by PLR to predict volume responsiveness	Bolus 500 mL of NaCl solution is administered for 10 minutes after PLR maneuver.	The PLR maneuver coupled with bioreactance monitoring was an accurate method of determining volume response in critically ill patients.

DISCUSSIONS

1) Implementation of PLR

Passive Leg Raising (PLR) is a temporary action that is reversible autotransfusion in nature to increase preload while (Pickett et al., 2017) passive leg raising test is one of the many strategies to assess fluid responsiveness (Rameau et al., 2017). Fluid responsiveness is an increase in stroke volume or cardiac output by 10% - 15% in response to 500 ml of the crystalloid fluid bolus (Pickett et al., 2017). CO monitoring to assess fluid responsiveness is performed before PLR, during PLR and after PLR (Minini et al., 2020). The peak effect of PLR occurs at 30-90 seconds during leg elevation (He & Liu, 2016). The PLR technique begins by providing a semi-recumbent position for 3 minutes and monitoring cardiac output. Then, the body is lowered in a supine position and the lower leg is passively raised at 45˚ horizontally which is therefore called PLR, leave it for 3 minutes and perform a cardiac output measurement for 30 seconds during leg elevation. Following that, the patient is returned to the initial position for 3 minutes and perform another the cardiac output measurement (Elwan et al., 2022; Toppen et al., 2020).

PLR indication is performed in patients with unstable hemodynamic status or poor tissue perfusion with systolic blood pressure manifestation < 90 mmHg, MAP < 60 mmHg, SVO2 < 65%, Heart rate > 100 x/m, urin output < 0,5 ml/kg/j, acral coldness, respiratory> 20 x/m, capillary refill time > 2, lactate: 2.0 mmol/L (Rameau et al., 2017). Contraindications occurred to patients with abnormal abdominal pressure (increased abdominal pressure) or patients with intra-abdominal hypertension (Beurton et al., 2019).

2) Advantages of PLR

a. PLR is a good predictor of fluid responsiveness.

PLR is a good predictor of fluid responsiveness in shocked patients. This occurs because PLR can increase venous return, resulting in an increase in the *diastolic volume of* the right ventricle followed by an increase in stroke volume of the left ventricle (Elwan et al., 2022). Fluid challenge is a gold standard for diagnosing responsiveness preload but variation in performing it might affect the results. Patients with a negative PLR test will most likely have the negative result if fluid bolus is performed (Elwan et al., 2022). If the patient is not responsive to fluids, then there is no need to administer additional fluids to the patient (Beurton et al., 2019).

Clinically, PLR has been shown to be effective in assessing fluid responsiveness in shocked patients and has been validated by different hemodynamic monitoring methods to measure cardiac output (Toppen et al., 2020). The PLR maneuver using accurate bioreactance monitoring determines volume response. Changes in carotid blood flow after the PLR maneuver is an additional and useful method for determining fluid responsiveness in hemodynamic unstable patients (Marik et al., 2013). An increase of SV > 10% in patients with acute circulatory failure during PLR will also increase peripheral perfusion seen from CRT responsiveness, i.e. a decrease in CRT by 27% during PLR (Jacquet-Lagrèze et al., 2019). Changes in pulse pressure variation induced by PLR can predict fluid responsiveness in patients with mechanical ventilation without cardiac arrhythmias monitored with arterial catheter (Mallat et al., 2022).

However, the effect of Passive Leg Raising (PLR) will be more accurate if the hemodynamic response is monitored directly using invasive CO (cardiac output) measurement than looking at arterial pulse pressure (Monnet et al., 2016). The PLR maneuver does not provide better results when hemodynamic monitoring is performed non-invasively (Kuan et al., 2016). PLR implementation provides relevant information on fluid responsiveness. However, PLR can also lead to reversible complications in patients with unstable hemodynamics, but these complications are rare. The results of the review suggest that there was a change in heart rate, MAP and atrial fibrillation and desaturation occurred in unconscious patients whereas conscious patients are subject to experiencing discomfort and pain (Toppen et al., 2020).

b. PLR can decrease fluid administration 48 hours after ICU admission

PLR test can be applied to a variety of clinical situations and has the potential to reduce fluid administration, as PLR mechanism is based on reversible autotransfusion. PLR can significantly and substantially reduce fluid administration in the first 48 hours of ICU admission in septic shocked patients. Fluid balance is generally significantly reduced (Rameau et al., 2017). The PLR-guided fluid resuscitation strategy leads to lower fluid balance where fluid volume administered at 72 hours becomes much less, thus, it will improve the function of vital organs that prevent complications of kidney and respiratory dysfunction in the first 72 hours of ICU admission (Douglas et al., 2020). Several study reviews proved that PLR induced fluid responsiveness assessment can reduce fluid needs in shocked patients, however PLR intervention does not significantly reduce body weight in shocked patients (Cronhjort et al., 2017).

Assessment of fluid responsiveness is strongly influenced by the technical and clinical aspects (Alvarado Sánchez et al., 2023). The implementation of PLR must be supported by the compliance of doctors and nurses to correct performance of PLR. In addition, correct hemodynamic measurements are required before, during and after PLR and the correct interpretation is highly crucial. Without the support of changes in therapeutic behavior of doctors and nurses in performing an effective PLR, reduction in fluid administration will not be necessarily achieved (Rameau et al., 2017). In addition, excessive use of PEEP and high dose of norepinephrine use ($\geq$ 0.3 mcg/kg/min) during PLR will affect the assessment results of fluid responsiveness (Alvarado Sánchez et al., 2023).

4. CONCLUSION

The findings of the present study identify the implementation and advantages of PLR. PLR has the practical benefits to assess fluid responsiveness in shocked patients. The assessment of fluid responsiveness may serve as a guide in performing fluid resuscitation in shocked patients. PLR can also decrease fluid administration in septic shocked patients for the first 48 hours of ICU admission. On average, fluid balance is significantly reduced. However, this should be supported by the compliance of doctors and nurses in performing PLR correctly. For that reason, health professionals especially critical care nurses should consider performing passive leg raising to shocked patients. Nonetheless, as the present study only used 2 main data bases, it is recommended that future research to use a larger number of data bases so that a more in-depth results of the implementation of passive leg raising in shocked patients and obstacles in its implementation can be observed.

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