The effect of passive leg raising maneuver on right internal jugular vein dimension in ICU patients under mechanical ventilation

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Abstract

Introduction: To improve accessibility, central vein catheterization in the upper body region is classically done in Trendelenburg position but it may impose potential disadvantages to respiratory system and disturb physiologic status of many other organs. Passive leg raising (PLR), a simple maneuver, widely used to improve cardiac preload and to predict patients' volume responsiveness could be an alternative.

Objectives: In this study, we evaluated the effect of PLR maneuver on right internal jugular vein (RIJV) dimension in intensive care unit patients under mechanical ventilation.

Methods: As a prospective study, twenty patients under synchronized intermittent mandatory ventilation (SIMV) without valvular heart problem or heart failure and acute respiratory distress syndrome were studied. RIJV dimension was measured with bedside ultrasonography of neck, first in supine position and then for second and third measurement, after 30° PLR for 1 and 5 minutes. Measurements were at the end of inspiratory cycle with positive end expiratory pressure of 5. We chose 30° PLR to keep bedridden patients away from possible damage that may be induced with higher upward slope.

Results: RIJV diameter increased with 30° PLR maneuver, and reached its utmost at 5 minutes in comparison to 1 minute point ($p < 0.0001$). Mean RIJV diameter was 10.2 mm in supine, increasing to 11.2 mm and 11.5 mm, 1 and 5 minutes after 30° PLR maneuver respectively. Increments in diameter were slightly lower than that associated with Trendelenburg position reported in other studies. No complication was noted.

Conclusions: PLR maneuver can be safely considered as an alternative to Trendelenburg position to increase internal jugular vein dimension in mechanically ventilated patients.

Key words: internal jugular vein, passive leg raising, mechanical ventilation, ultrasonography

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Introduction

Passive leg raising (PLR), a maneuver of bringing both legs up from supine position, is a surviving method used by emergency paramedics in times of circulatory collapse. Recently this procedure has been under interest for assessing hemodynamic status and diagnosis of intravascular volume depletion as it is observed that it could increase cardiac preload(1) easily and non-invasively. Raising legs induces transferring of blood reserved in lower extremities to the central compartment and finally to the heart. In a study on radioactive tagged erythrocytes, following PLR, blood content of calves depleted about 150 cc and this volume of venous return enhances circulation by augmenting right ventricle preload(2).

Multiple studies show different aspects of hemodynamic change following PLR such as increase in pulmonary artery occlusion pressure(3,4), end diastolic dimension of left ventricle (3,5), enhancing E wave of mitral valve flow(3,6,7), prolongation of left ventricle ejection(8), also improving sublingual microcirculation and perfusion(9). All of these changes confirm that the volume of blood redistributing after PLR is sufficient to possibly expand left heart preload. Surprisingly, preload expansion disappears after returning legs to supine position thus this maneuver is assumed as a reversible intervention(4,8,10,11). Furthermore, some studies indicate that PLR is capable of boosting cardiac output such as intravascular administration of 300 cc colloid even in patients under mechanical ventilation (MV) (4). Moreover this enrichment is not affected by arrhythmia or ventilator setting. In a survey of 71 patients suffering from hemodynamic shock, PLR increases aortic flow time, a marker of increased left ventricle preload. Also it is proved that PLR can be used as a measure to anticipate responsive and non-responsive patients in time of fluid therapy(8).

Central vein catheterization (CVC) is a standard way of measuring central vein pressure and a route of vasoactive drugs` and chemotherapy agents` administration as well as intravascular volume resuscitation or evacuation of embolized air bubble in affected patients. This is a safe method for multiple sampling in admitted patients when peripheral lines are not accessible. More than that, through central veins we can install temporary hemodialysis, catheterize pulmonary artery or implant pacemaker`s wires(12). From the introduction of this method in 1960, right internal jugular vein is the most preferred location by the anesthesiologist to access upper body central veins(13,14). A maneuver conventionally tried for successful catheterization is to lower head below body level, known as Trendelenburg (TDB) or head down position, which makes cervical veins congest, and helps to reach central veins more easily (15,16,17).

Unfortunately, TDB position has serious consequences on cardiovascular, respiratory and cerebral systems. In a review study on more than 290 articles in 2010, authors concluded that this position not only causes disadvantage on cardiac output but also some undesirable effects observed even after returning patient back to supine position(18). Also seen is increased intra-cranial and ocular pressure(19,20), edema of face, eyes, tongue and larynx with feasible risk of upper airway obstruction, when individuals are placed in head down position for a long period of time. Besides that, patients are in danger of regurgitation or aspiration due to upper displacement of stomach(20,21). Moreover functional residual capacity of lung diminishes, leads to aggravation of breathing work in individuals with spontaneous respiration as intra abdominal organs are pressing on the diaphragm as well as in patients under MV in some settings (e.g. peak airway pressure) should be changed to maintain adequate ventilation(22,23).

Due to near similar consequences of both PLR and TDB on increase of jugular vein dimension, we evaluated the possibility of using PLR as an alternative maneuver. The effect of PLR to expand right internal jugular vein already has been determined in healthy volunteers in relation to controls, in a study performed by Kim et al. Their measurements showed about 25% increases in vein diameter ($P < 0.0001$) but it was lower than TDB change (25% vs. 48%), they noted (24). Another study in 2013 on anesthetized pediatric cases with cardiac shunts, candidates for repairing of congenital heart diseases, demonstrated that both maneuvers were successful in engorgement of jugular vein(25). Considering the necessity of access to central veins in critical care units, where patients are usually ventilated by mechanical ventilators and in situations when TDB or head down position is harmful to particular patients, PLR advantages should be confirmed again. If we want to apply this method, the first step will be demonstrating PLR effects in increasing jugular vein diameter.

Materials and methods

Our study is a prospective clinical trial performed on 20 patients aged between 20 to 70 years, admitted in intensive care unit (ICU) under MV with synchronized intermittent mandatory ventilation (SIMV) mode. Unstable respiratory and cardiovascular patients or those in danger of complications due to change in position or whose treatment processes were threatened by our intervention (e.g. patients with lower extremity fracture or deep vein thrombosis) were excluded. To avoid confusion in interpreting results, cases with any type of valvular or congenital heart disease, heart failure, pericarditis or pericardial effusion were also refused. Likewise, patients sufferering from abdominal compartment syndrome, with history of trauma and surgery in neck and patients receiving intravascular inotropes or vasoactive drugs were not involved.

Our purpose was to examine possible effects of PLR in right internal jugular vein (RIJV) dimension and for exact evaluation we tested it in three separate phases. At the first phase (supine pre-test), cases were examined with portable bedside Doppler sonography, RIJV dimension and cross sectional area were measured. In the second

(PLR phase) both legs were raised straight up to 30 degrees, stabilized as safe and then measuring repeated, 1 and 5 minutes after staying in PLR position. In the last phase (supine post-test) we returned legs to supine and after 5 minutes remaining in flat position, RIJV diameter and cross sectional area were measured again with the aid of Doppler sonography. Thus we evaluated each patient at four time points and recorded 8 measurements for each case to be compared later. The intervention sequences are shown in Figures.1 and 2.

Ultrasonography device SonoSite®M-Turbo was used and the same vascular probe (HFL 38 E) applied for all cases. Method of sonographic evaluation (depth, place and direction of probe) followed standard studies(15.26.27). Patient`s head was stabilized in neutral posture, without flexion or extension, then slowly turned about 20 degrees to left side. In this position and at the level of cricoid cartilage, the maximum anterior-posterior RIJV diameter and cross-sectional area were measured with minimal pressure to avoid vascular compression. We saved each ultrasonic frame of displayed view to be studied later, for further evaluation, by another examiner. This blinded radiologist supervisor repeated measurements on recorded images and was not informed about patients` positions or intervention phases while frames were captured. We observed periodical fluctuations in vein diameter due to ventilation cycle, however we recorded maximal diameter on assisted ventilation. During the intervention we carefully monitored patients to interrupt examination in times of medical instability, although we did not encounter any complication during study phases.

Results

We studied twenty cases, 11 men and 9 women; mean of age was 50.5 as the youngest was 25 and the oldest was 75 years old. All of them were ventilated by SIMV mode, set tidal volumes were 6 to 8 cc/kg and positive end expiratory pressure (PEEP) was 5 cmH2O. Patients were not completely paralyzed but were completely comfortable and had spontaneous breathing, sometimes. Data were analyzed with SPSS®ver.21 and paired t-test. Difference of RIJV diameter and cross-sectional area in supine position versus one and five minutes after PLR showed to be significant ($p < 0.0001$). Mean RIJV diameter in supine position (1st phase) was 10.2 mm, that was increased to 11.2 (9%) and 11.5(12%) mm, one and five minutes after PLR (2nd phase) respectively and decreased again to 10.6 mm 5 minutes after returning to supine position (3rd phase) (Figure 2). Mean of RIJV cross-sectional area in supine position (1st phase) was 1.25 cm2, that was increased to 1.40(12%) and 1.49(19%) cm2, one and five minutes after PLR (2nd phase) respectively and decreased again to 1.26 cm25 minutes after returning to supine position (3rd phase) (Table 1) (Figures 3 and 4).

Figure 1. Sequence of study phases on patients (black arrow: time of measuring)

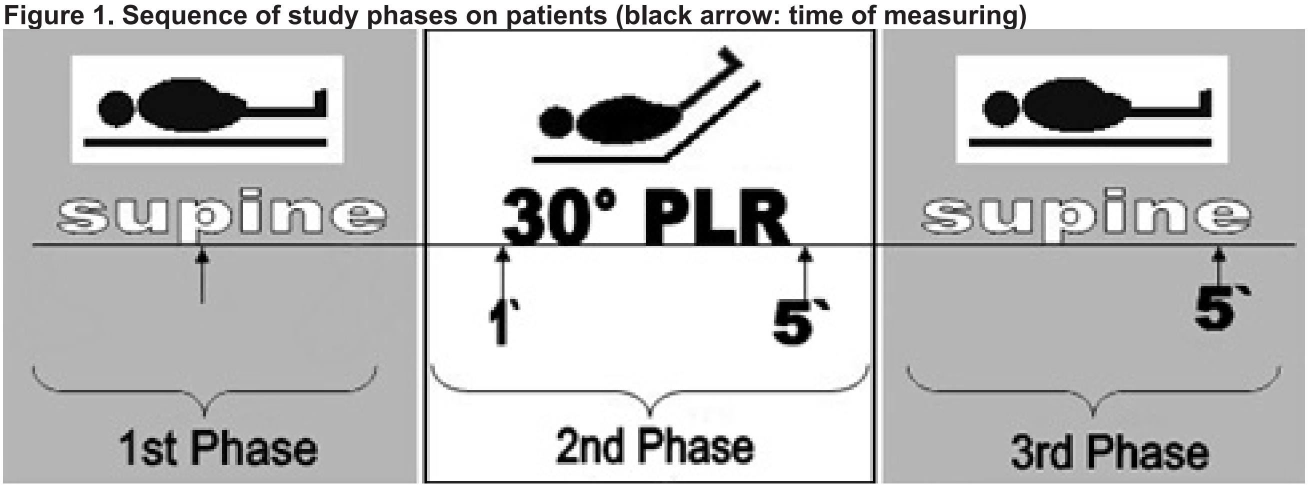


Table 1: Results

Means	SUPINE Pre-test	30°PLR		SUPINE Post-test
		1min	5min	
RIJV Diameter (mm)	10/2	11/2	11/5	10/6
RIJV Cross-Sectional Area (cm²)	1/25	1/40	1/49	1/26

Figure 2: An example of measuring and saved frames of displayed ultrasonography views in different study phases (v: right internal jugular vein)

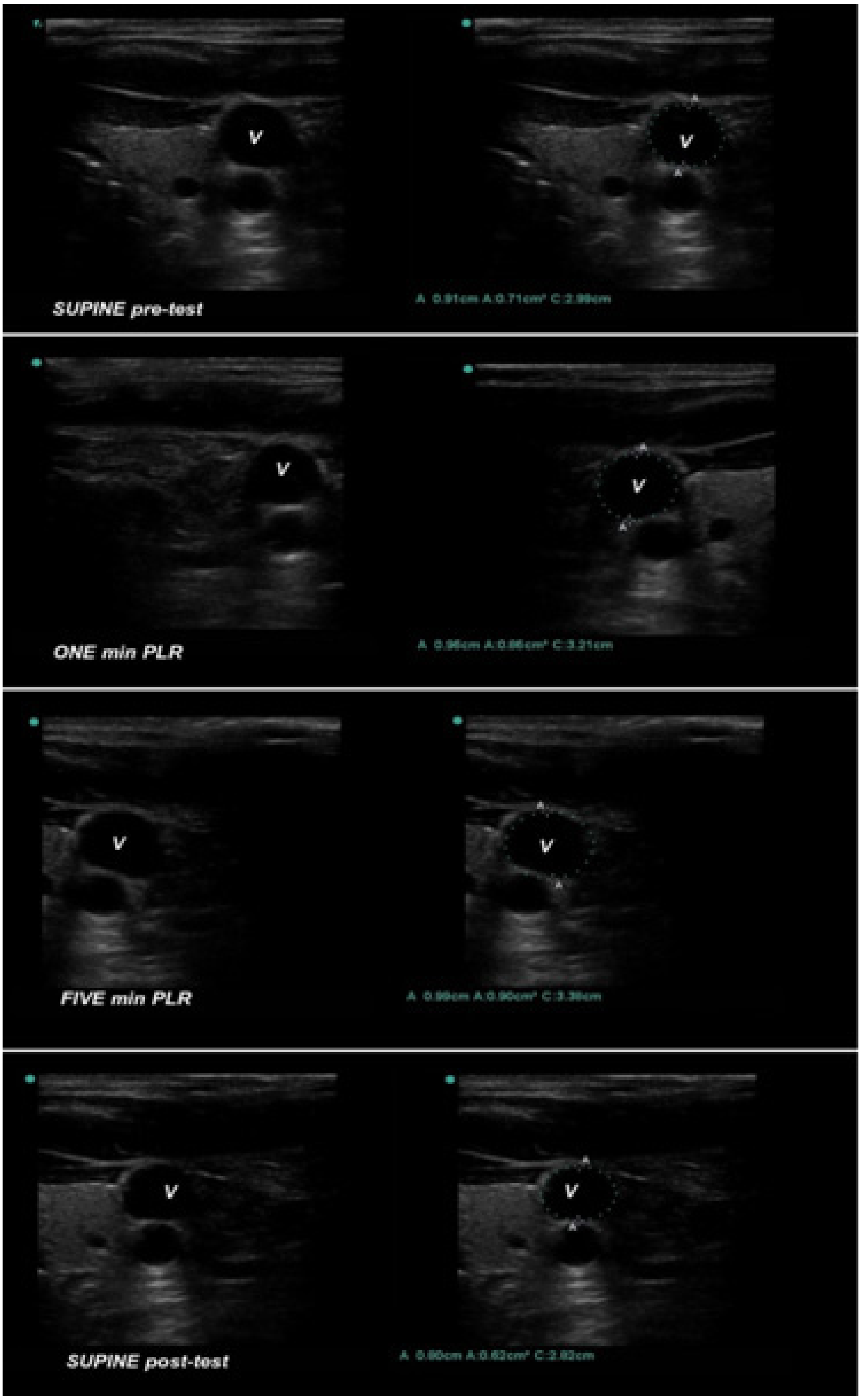


Figure 3: Changing in RIJV diameter during study phases

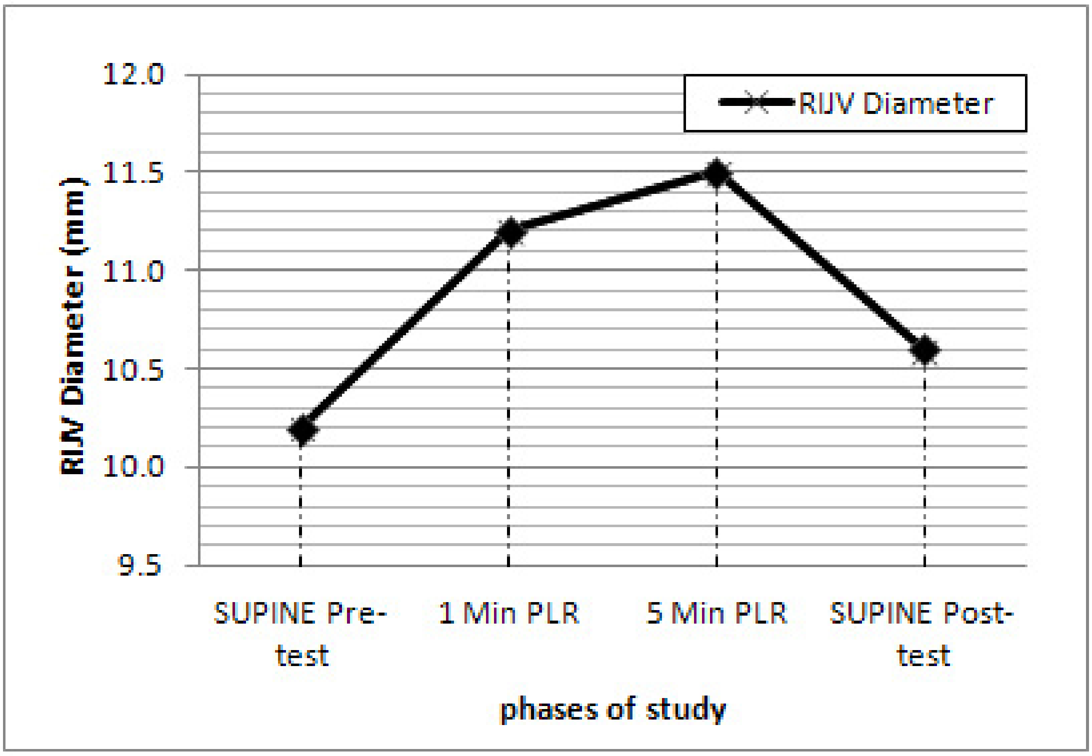
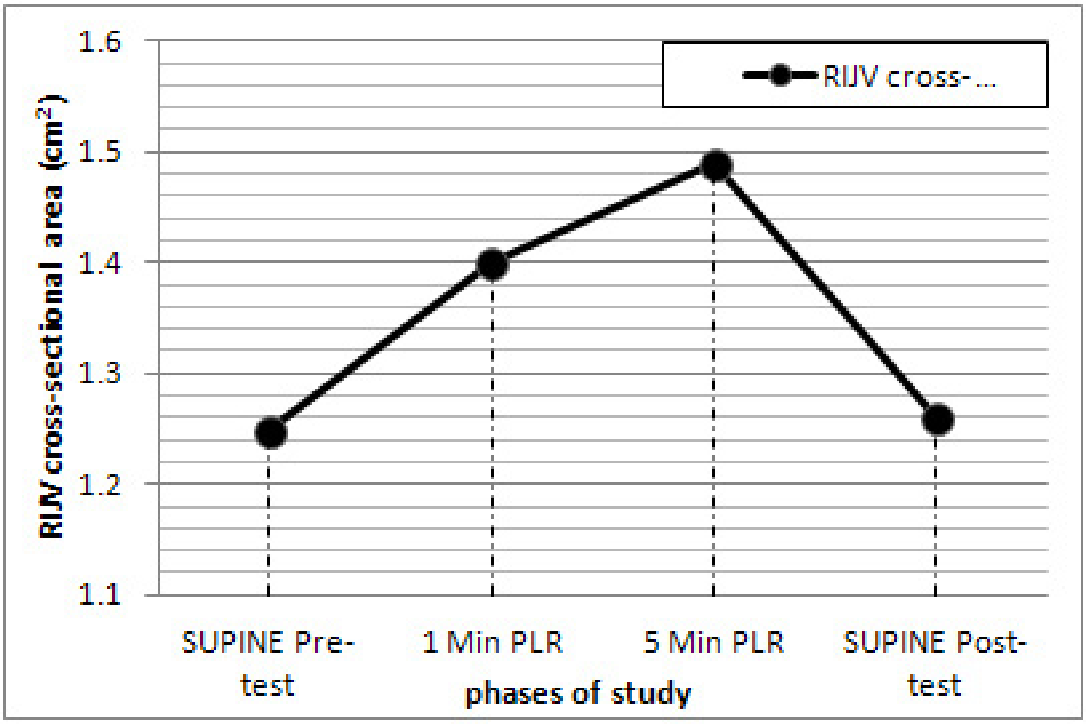


Figure 4: Changing in RIJV cross-sectional area during study phases



Discussion

Change in RIJV diameter and cross-sectional area after 30° PLR in comparison to supine position was significant. Venous engorgement was more obvious after five minutes sustained leg elevation. Additionally, increase in cross-sectional area of vein denoted that enhancement occured in multiple, not only one direction. Extent of increased cross-sectional area after 5 minutes seems to be enough (19%) that may be considered to facilitate RIJV catheterization. To prove that rise in diameter and surface area of RIJV were caused by PLR and were rapidly reversible, we repeated measurements, five minutes after returning the legs to neutral position. A little difference between 1st versus 3rd phase measurements indicate that venous size alteration is transient and reversible and PLR does not induce permanent effects as revealed in other studies(4,8,10,11).

Increase in diameter and cross-sectional area of RIJV has been already investigated in previous studies on healthy volunteers but we wanted to demonstrate its effects in ICU patients under MV. Application of positive pressure ventilation leads to multiple hemodynamic changes in patients which to a great extent, depend on their basic condition and ongoing status. In spite of the fact that there are too many factors to be considered, it is almost impossible to find similar ICU patients with exact similar conditions. Moreover, if a specified group of the same patients had been chosen, the result of study would be limited to that small group only. Although our patients had different intravascular volume, cardio-respiratory and hemodynamic status at the time of intervention and showed different amounts of alteration, changing style in RIJV size was identical among cases.

According to study of Kim et al(24), RIJV cross-sectional area was 1.12 cm2 reaching to 1.40 cm2 after one minute 50° leg raising ($p < 0.0001$). These findings are similar to our results but smaller changes in our cases might be due to lesser degree of leg raising (30°vs. 50°). In respect to ICU patients` vulnerable situation and to prevent plausible injury induced by coarse or excessive displacement, we were limited to PLR to 30°. Nonetheless, to clarify the exact size suited for RIJV catheterization with the least risk to patients requires further studies.

Many surveys concluded that increment in RIJV dimension after TDB position, is more than PLR maneuver(17,24,25,28,29). This is probably due to excessive blood which redistributes from lower, central and upper parts of body toward head and neck, in comparison to PLR maneuver that only draws in lower extremity blood. The goal of our study is just to show the effects and extent of PLR maneuver on RIJV dimensions; the first essential step to utilize this maneuver in catheterization.

Although positive results were achieved by this study, it had some limitations. One of the most challenging subjects is bias related to examiner, the fact that exists in all studies where a specific person or tool used to measure a variable. For all cases in our study, examiner was a specified and constant physician who was inevitably aware of patient position. We tried to minimize this bias by saving displayed frames and measured them again by another blinded examiner, who did not know anything about patients` positions or phases of intervention. Our study encompassed a limited group of ICU patients. We excluded patients suffering from hemodynamic or respiratory instability, therefore limiting external validity of our results. However, it could be suggested to health-care providers to apply PLR for internal jugular catheterization, when other conventional positions may have undesirable consequences. Further studies focusing on PLR facilitation of catheterization should be undertaken.

Conclusion

Passive leg raising maneuver can be safely considered as an alternative to Trendelenburg position to increase internal jugular vein dimension in mechanically ventilated patients. Future studies are needed to clarify possible pros and cons of PLR when utilized for central venous catheterization.

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