

Influence of various positive airway pressure levels on catheterization of the right internal jugular vein



Renganathan S¹, Ramji R², Ganesh Prabhu SC³

¹Assistant Professor, ²Senior Resident, ³Professor, Department of Anaesthesia, Velammal Medical College and Research Institute, Madurai, Tamil Nadu, India

Submission: 03-11-2023

Revision: 28-12-2023

Publication: 01-02-2024

ABSTRACT

Background: Central venous catheterization is a commonly used method of administering drugs and measuring central venous pressure during major surgery. Chronic obstructive pulmonary disease, acute respiratory distress syndrome, and obstructive sleep apnea are among the respiratory disorders that can be treated with positive airway pressure (PAP). While PAP therapy benefits patients with respiratory disorders, its impact on central venous catheterization must be more adequately studied, particularly in the right internal jugular vein (RTIJV). **Aims and Objectives:** The study aimed to predict the most applicable PAP for RTIJV catheterization and to evaluate the complications with different airway pressures. **Materials and Methods:** This study was conducted using a comparative prospective randomized control trial study design in a tertiary care hospital. One hundred participants were selected from subjects who came for gastrointestinal tract surgery and urological surgery, and they were randomized through a computer-generated random number table. **Results:** Participants were divided into four different groups (A, B, C, and D), and they were subjected to four pressures 0 cmH₂O, 10 cmH₂O, 15 cmH₂O, and 20 cmH₂O, respectively. The cross-sectional area of RTIJV is significantly increased in Groups C and D compared to Groups A and B. The number of completed catheterizations was higher in Groups C and D. The number of first-pass punctures was also higher in Groups C and D. Depth of needle insertion is significantly reduced with increased pressure. **Conclusion:** Moderate-to-high PAPs, specifically around 15 cmH₂O to 20 cmH₂O, boost catheterization success. This is achieved through improved vein dilation, enhanced accuracy, and decreased needle insertion depth.

Key words: Right internal jugular vein catheterization; Positive airway pressure; Central venous catheterization; First-pass punctures; Right internal jugular vein cross-sectional area

INTRODUCTION

The right internal jugular vein (RTIJV) is a common insertion site for central venous catheterization due to its relatively easy access and low risk of complications.¹ However, the procedure can become challenging in specific clinical scenarios, such as patients with compromised cardiac function or undergoing positive airway pressure (PAP) therapy.² Central venous catheterization may be lifesaving, but its performance requires critical operator training and experience. A prior

study showed that >15% of patients who received central venous catheterization suffered complications.³ Ultrasound-guided central venous catheterization has been reported to reduce the frequency of mistaken arterial punctures.⁴

The impact of PAP on RTIJV catheterization depends on factors such as the patient's medical condition, the specific PAP settings, the experience of the health-care provider, and the overall clinical context.⁵ A large IJV can increase the success rate of first-pass attempts.⁶ Thus, several

Access this article online

Website:

<http://nepjol.info/index.php/AJMS>

DOI: 10.3126/ajms.v15i2.59540

E-ISSN: 2091-0576

P-ISSN: 2467-9100

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Address for Correspondence:

Dr. Renganathan S, No. 2. Ara Nivas Near Ywca School, Vallabhai Road, Chokkikulam Madurai - 625 002, Tamil Nadu, India.

Mobile: +91-9500025879. E-mail: enganathansockalingam@gmail.com

investigators have proposed methods to engorge the vein.⁷ An increase in PAP is directly related to an increase in central venous pressure (CVP).⁸

Given the limited evidence regarding the effects of different PAPs on RTIJV catheterization, this study aimed to systematically investigate and compare the influence of four distinct PAP settings on procedural success, complications, and hemodynamic changes during RTIJV catheterization.

Aims and objectives

The study aimed to predict the most applicable PAP for RTIJV catheterization and to evaluate the complications with different airway pressures.

MATERIALS AND METHODS

Study setting

The study was conducted in Velammal Medical College Hospital, in the Department of Anaesthesiology.

Study design

The study was conducted using A Comparative prospective randomized control trial.

Study period

The study was conducted between March 2022 and December 2022.

Inclusion criteria

BMI <29.9 KG/M², Patients with 19–50 years of age were included in the study.

Exclusion criteria

BMI >30 kg/M², External neck injuries, previous right internal jugular vein (RTIJV) catheterization, cardiovascular disease, RTIJV thrombosis, Pregnant women, Injection site infection, Patients who refused to participate in the study were excluded from the study.

Sample size

This study has included 100 participants (Figure 1).

Randomization

Randomization of the study participants was done through a computer-generated random number table into four groups (A, B, C, D). Participants were divided into four groups, each group subjected to PAP values of 0 cmH₂O, 10 cmH₂O, 15 cmH₂O, and 20 cmH₂O, respectively.

Allocation concealment

A sequentially numbered, Opaque, Sealed envelope technique was used for allocation concealment.

Blinding

Only participants were blinded while doing the intervention.

Intervention

Participants were divided into four groups A, B, C, and D, respectively, and vitals were monitored throughout the procedure. Induction of anesthesia was done using propofol 2–2.5 mg/kg and fentanyl 2 µg/kg and neuromuscular blockade was performed with rocuronium 0.6 mg/kg. Following anesthesia induction, each patient was positioned with their head in a neutral or nearly neutral posture and in a 15° Trendelenburg position without the use of pillows. Care was taken to ensure that the RTIJV was not compressed when applying the ultrasonic probe perpendicularly to the skin at the level of the cricoid cartilage. In Group A, the cannulation needle was advanced gradually while maintaining a steady negative pressure on the syringe and a 35–45° angle between the needle and the skin in the absence of mechanical ventilation (0–cmH₂O PAP). Group B experienced a mechanically produced PAP of 10 cmH₂O while the cannulation needle was advanced gradually. After the guide wire was placed, this pressure was removed. In Groups C and D with the airway pressure increased to 15 and 20 cmH₂O, respectively, RTIJV catheterization was carried out in the same manner as in Group B. In each group, PAP was not maintained for more than 45 s.

Ethical approval

The study was approved by the intuitional ethical committee of Velammal Medical College Hospital and Research Institute on March 15 2022 (IEC No: VMCIEC/06/2022). Informed written consent was taken from all the participants. Confidentiality of the study participants was maintained throughout. Clinical trial registry of India registration was done (CTRI/2022/05/042744). All participants agreed to and signed the informed consent before the examination.

Statistical analysis

Descriptive analysis was carried out by frequency and proportion for categorical variables. Continuous variables were presented as mean±SD or median (interquartile range [IQR]). Chi-square test was used to test the statistical significance of cross-tabulation between categorical variables. A one-way analysis of variance test was used to compare the mean±SD of continuous variables between four groups. Kruskal–Wallis H test with Bonferroni *post hoc* test was used to compare the median (IQR) of continuous variables between four groups. P<0.05 was considered statistically significant. Data were analyzed using coGuide software.⁹

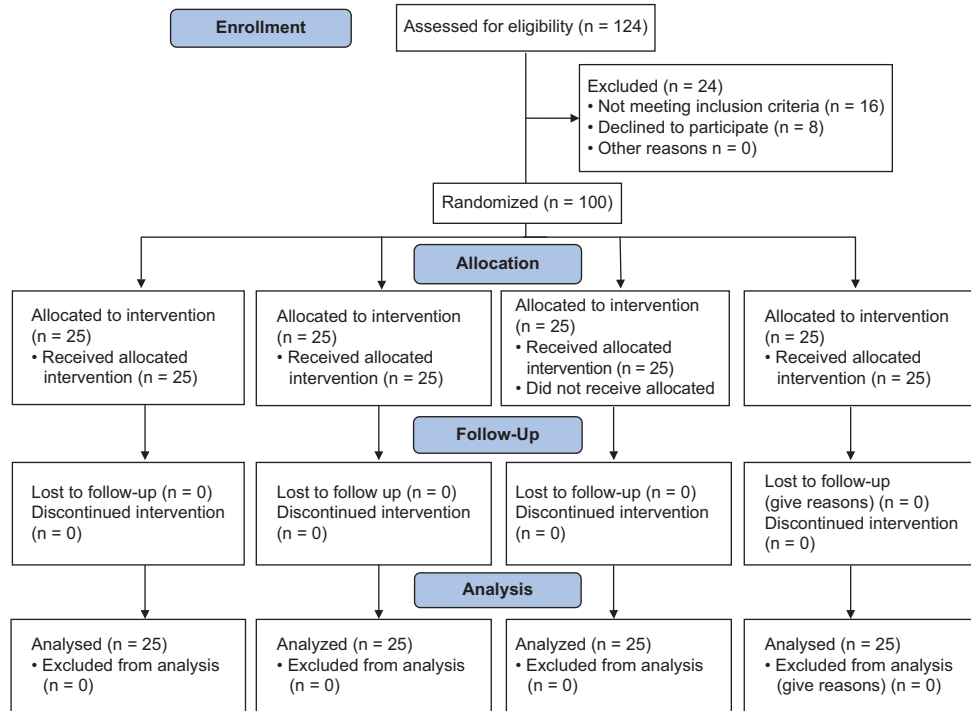


Figure 1: Consort 2010 flow diagram

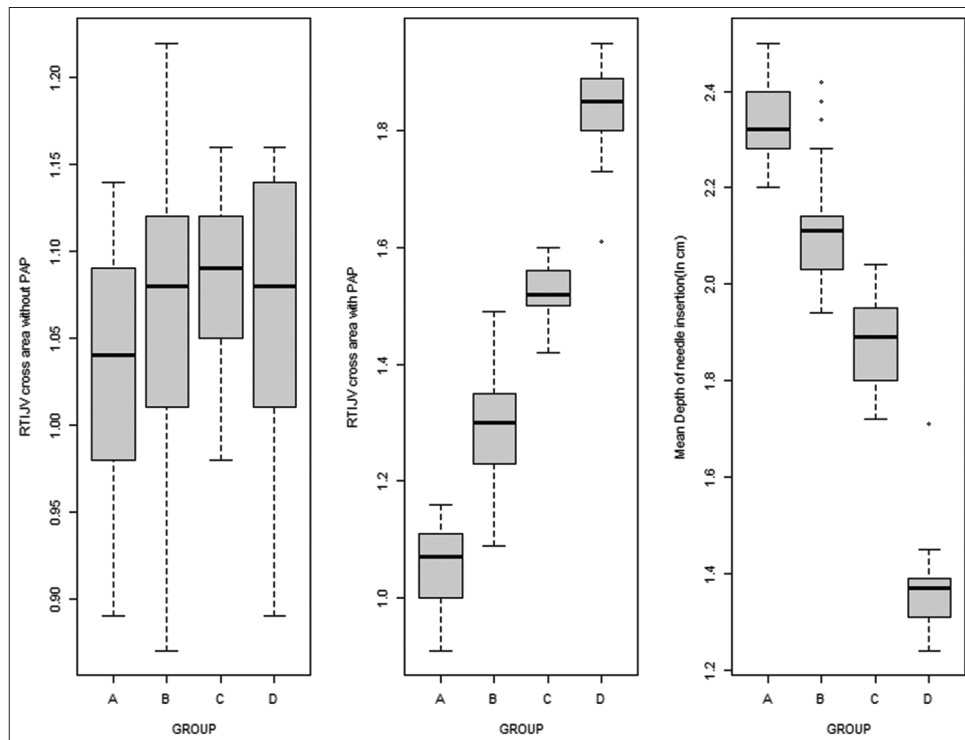


Figure 2: Comparison of outcome parameters across the study group

RESULTS

Participants were divided into four different groups (A, B, C, and D) randomly with a computer-generated

random number table and subjected to four different pressures 0 cmH₂O, 10 cmH₂O, 15 cmH₂O, 20 cmH₂O, respectively, to find out which is the suitable amount of PAP for RTIJV catheterization.

Table 1: Comparison of participant characteristics across groups

Parameter	Group				P-value
	A (%)	B (%)	C (%)	D (%)	
Age	42.2±11.78	45.15±10.14	43.88±11.73	40.48±13.39	0.477
Gender					
Female	11 (44)	11 (44)	13 (52)	11 (44)	0.923
Male	14 (56)	14 (56)	12 (48)	14 (56)	
Height	160.92±9.8	161.77±9.3	164.58±10.18	164.04±10.55	0.320
Weight	62.64±10.05	64.69±8.84	67.13±10.59	68.28±10.43	0.111
ASAP					
1	7 (28)	6 (24)	10 (40)	13 (52)	0.246
2	14 (56)	15 (60)	9 (36)	7 (28)	
3	4 (16)	4 (16)	6 (24)	5 (20)	

ASAP: American Society of Anesthesiologists Physical status

Table 2: Comparison of outcomes of various parameters across study groups (n=100)

Parameter	Group	Median (IQR)	P-value (Kruskal–Wallis H test)	P-value (Bonferroni <i>post hoc</i> test)					
				A versus B	A versus C	A versus D	B versus C	B versus D	C versus D
RTIJV cross area without PAP	A (n=25)	1 (1.0, 1.1)	0.119	1.000	0.119	0.501	1.000	1.000	1.000
	B (n=25)	1.1 (1.0, 1.1)							
	C (n=25)	1.1 (1.0, 1.1)							
	D (n=25)	1.1 (1.0, 1.1)							
RTIJV cross area with PAP	A (n=25)	1.1 (1.0, 1.1)	<0.001	0.025	<0.001	<0.001	0.012	<0.001	0.012
	B (n=25)	1.3 (1.2, 1.4)							
	C (n=25)	1.5 (1.5, 1.6)							
	D (n=25)	1.8 (1.8, 1.9)							
Depth of needle insertion	A (n=25)	2.3 (2.3, 2.4)	<0.001	0.059	<0.001	<0.001	0.010	<0.001	0.010
	B (n=25)	2.1 (2.0, 2.1)							
	C (n=25)	1.9 (1.8, 1.9)							
	D (n=25)	1.4 (1.3, 1.4)							

RTIJV: Right internal jugular vein, IQR: Interquartile range, PAP: Positive airway pressure

Table 3: Comparison of outcome parameters across study groups (n=100)

Parameter	Group				P-value
	A (n=25) (%)	B (n=25) (%)	C (n=25) (%)	D (n=25) (%)	
Catheterization completed in 45 s	17 (68)	19 (76)	23 (92)	21 (84)	0.19
First pass punctures	15 (60)	17 (68)	23 (92)	24 (96)	0.003

Table 4: Comparison of complications across study groups (n=100)

Complications	Group				P-value
	A (n=25) (%)	B (n=25) (%)	C (n=25) (%)	D (n=25) (%)	
Local hematoma	3 (12)	2 (8)	1 (4)	3 (12)	0.719
Hypotension	1 (4)	2 (8)	1 (4)	7 (28)	0.028
Bradycardia	1 (4)	3 (12)	1 (4)	7 (28)	0.028

The Table 1 depicts that all the characteristics among the groups are found to be similar in the study population.

The Table 2 and Figure 2 shows that the cross-sectional area of the RTIJV is increasing with the increase in PAP. The mean depth of needle insertion is significantly reduced with increased pressure.

The Table 3 indicates that there is no statistically significant variation in the success rates among the study groups

concerning Catheterizations completed within 45 (P=0.19). In addition, it is observed that with increasing pressure, the number of first-pass punctures also rises in the case of first-pass punctures.

The above Table 4 states that the difference in the proportion of local hematoma across the study group was found to be similar. Hypotension and bradycardia were significantly higher in Group D when subjected to 20 cm H₂O PAP.

DISCUSSION

The study aimed to investigate the effects of various PAP on RTIJV catheterization.

The study groups were comparable in terms of age, gender distribution, height, and weight. This similarity enhances the internal validity of the study, reducing the potential for confounding variables to influence the results.

The assessment of various outcome parameters yielded significant insights into the impact of PAP on catheterization success. The cross-sectional area of the RTIJV increased progressively with higher PAP, indicating that increased pressure might contribute to vein dilation and facilitate catheter insertion. This finding aligns with the notion that PAP can enhance vascular accessibility by augmenting vessel size.

Furthermore, the study demonstrated that the number of completed catheterizations was higher in Groups C and D, suggesting that moderate-to-high PAPs might enhance catheterization success rates. In addition, the number of first-pass punctures was also higher in these groups, indicating that increased pressure could potentially improve the accuracy of needle insertion on the first attempt.

One of the significant findings was that the mean depth of needle insertion decreased with increasing PAP. This implies that higher PAP might lead to easier and shallower needle insertion, reducing the risk of complications associated with deeper punctures. This finding aligns with the idea that appropriate PAP might aid in optimizing the catheterization procedure.

A similar study found that when the PAP was 20 cmH₂O, the average number of attempts required for successful puncture was 1.05, the rate of puncture on one attempt was 96.7% and catheterization time was reduced.¹⁰ Several studies have documented that the utilization of ultrasound guidance during IJV catheterization leads to enhanced success rates, reduced puncture time, and a decrease in complications.¹¹⁻¹³ A number of factors, including equipment availability and practitioners' attitudes toward its utility, have constrained the broader adoption of ultrasound guidance for central venous catheterization, as indicated by various studies.^{14,14-17} The fundamental concept behind how PAP operates to enlarge the cross-sectional area of the RTIJV and elevate CVP in the context of general anesthesia involves the concurrent elevation of thoracic pressure and right atrial pressure. This elevation subsequently causes an augmentation in the blood volume within the RTIJV, leading to its expansion. Sustained PAP usage is linked to an increased likelihood of hypotensive events.¹⁸⁻²¹

Limitations of the study

The study was conducted in a single medical college hospital, which may limit the generalizability of the results to broader populations or different health-care settings. The findings might not accurately represent diverse patient populations or other healthcare environments. The sample size of 100 participants, divided into four groups, might limit the statistical power to detect smaller differences. Patients with a variety of underlying illnesses were included, which can affect the results. In addition, the study focused on short-term effects, and the long-term implications of different PAPs on catheterization were not explored.

CONCLUSION

The results suggest that moderate-to-high PAPs, particularly in the range of 15 cmH₂O to 20 cmH₂O, might enhance catheterization success rates by facilitating vein dilation, improving accuracy, and reducing the depth of needle insertion. However, the study also emphasizes the importance of carefully considering the potential complications associated with higher pressures, such as hypotension and bradycardia. Further research could explore the long-term effects and individual patient factors in greater depth to provide a comprehensive understanding of optimizing catheterization procedures.

ACKNOWLEDGMENT

We acknowledge the technical support in data entry, analysis, and manuscript editing by "Evidencian Research Associates."

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Authors Contribution:

RS- Has conceptualized the study and played primary role in compiling, analysis, and interpretation of the data. All the drafts were prepared, reviewed, and final draft was approved by; **RS, RR, and GPSC**- Have contributed in fine tuning of the proposal, contributed in data collection and entry. Reviewed the results and contributed to preparation and review of drafts. All the authors have read and approved final version of the manuscript. All the authors take complete responsibility for the content of the manuscript.

Work attributed to:

Velammal Medical College Hospital, Madurai, Tamil Nadu, India.

Orcid ID:

Renganathan S - <https://orcid.org/0000-0002-2578-8645>

Ramji R - <https://orcid.org/0000-0002-7671-710X>

Ganesh Prabhu SC - <https://orcid.org/0009-0001-1222-9713>

Source of Support: The project was self-funded. No external agency had funded the project, **Conflicts of Interest:** None declared.