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RESEARCH ARTICLE

THE EFFECT OF RIGID CERVICAL COLLAR ON INTERNAL JUGULAR VEIN DIMENSIONS: AN ULTRASOUND STUDY

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Abstract

Objectives: Rigid cervical collars are routinely used for spinal immobilization in trauma patients, particularly those with head injuries, to prevent further neurological damage. However, concerns exist that these collars might increase intracranial pressure (ICP), potentially exacerbating secondary brain injury. While the exact mechanism for this ICP rise is unclear, one proposed theory is obstruction of venous outflow from the neck. This study aimed to investigate the effect of rigid cervical collars on the dimensions of the internal jugular vein (IJV) using ultrasound, providing insight into the potential mechanism for increased ICP.
Methods: Eighty healthy volunteers participated in a prospective observational study. Ultrasound was used to measure the cross-sectional area (CSA) of both the right and left internal jugular veins before and after the application of a rigid cervical collar. The measured areas were then compared.
Results: The cross-sectional area of both the right and left internal jugular veins increased significantly after the application of the rigid cervical collar ($p<0.001$), irrespective of the volunteer's age and sex. The mean increase in CSA for the right IJV was 3.61±1.72 mm2, and for the left IJV, it was 3.55±1.81 mm2.
Conclusions: The application of a rigid cervical collar leads to a significant increase in the cross-sectional area of the internal jugular veins in healthy volunteers. This finding supports the hypothesis that venous obstruction in the neck may contribute to the observed increase in intracranial pressure following rigid cervical collar application. Consequently, in head-injured patients, rigid collars should be removed as soon as cervical spine injury is ruled out, or alternative immobilizati on methods should be considered if delayed removal is necessary.

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Introduction:-

Rigid cervical collars (RCCs) are a cornerstone of Prehospital and Emergency Department trauma care, essential for provisional immobilization of the cervical spine in patients with suspected spinal cord injury (SCI) [1, 2]. By

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restricting head and neck movement, these devices are intended to prevent secondary neurological injury until formal cervical spine clearance is achieved. However, the routine application of rigid immobilization is increasingly debated due to mounting evidence suggesting a potentially detrimental secondary effect: an increase in intracranial pressure (ICP) [3, 4].The mechanism underlying this rise in ICP is hypothesized to be the mechanical compression of the major cerebral venous outflow pathways, namely the internal jugular veins (IJVs), by the collar structure [5, 6]. The internal jugular veins are the primary conduit for venous drainage from the brain, and their compression impedes flow, leading to increased intracranial blood volume in accordance with the Monro-Kellie doctrine [7]. This resultant intracranial hypertension is of critical concern, particularly in patients with co-existing traumatic brain injury (TBI), where cerebral perfusion pressure (CPP) may already be compromised, risking further neurological deterioration [3, 8].

While several studies have demonstrated a statistically significant increase in ICP following the application of an RCC, the direct visual evidence linking the collar's application to quantitative changes in IJV dimensions in vivo is variable and requires further high-quality investigation [6, 9]. Ultrasound (US) is a non-invasive, accessible, and dynamic imaging modality uniquely suited for assessing changes in vein cross-sectional area (CSA) and flow in response to external mechanical forces [10]. Previous work utilizing Ultrasound has suggested that cervical collars may, paradoxically, lead to an increase in IJV cross-sectional area, supporting the venous obstruction hypothesis by indicating a proximal flow impedance and subsequent distension [6].Given the ongoing clinical necessity of spinal immobilization and the critical risk associated with elevated ICP, a precise understanding of the mechanical effect of RCCs on venous drainage is paramount. Therefore, the objective of the current study is to use high-resolution ultrasound to systematically measure and quantify The Effect of Rigid Cervical Collar on Internal Jugular Vein Dimensions in a cohort of healthy volunteers, providing robust, quantitative data to clarify the mechanism of cerebral venous outflow obstruction.

Materials and Methods:-

Study Design and Setting:

This was a prospective observational study designed to evaluate the acute effect of rigid cervical collar application on the internal jugular vein (IJV) cross-sectional area (CSA) in healthy volunteers. The study was conducted over an eight-month period, from April 2024 to November 2024, at a tertiary care hospital in India. The study protocol, including the consent process, was comprehensively reviewed and received ethical approval from the Institutional Ethics committee. Healthy adult volunteers who willingly provided informed consent were included in this study. Volunteers with any pre-existing deformity of the neck, or medical conditions such as syncope that could potentially interfere with the study procedure or compromise safety, were excluded from the study.

Sample Size and Participant Recruitment:

The required sample size was determined using a standard formula for comparing dependent means (paired samples), as the measurement was taken within the same individuals before and after the intervention The calculation assumed a two-sided significance level (α) of <0.05 (corresponding to $Z_{\alpha/2}=1.96$ a study power of 80% (corresponding to $Z_{1-\beta}=0.84$) and an anticipated effect size (d) of 0.11 for the change in the cross-sectional area of the right internal jugular vein with and without the rigid cervical collar. Based on these parameters, the minimum required sample size was calculated as n=80. Accordingly, a total of 80 healthy volunteers were recruited for the study.

Data Collection and Measurement Protocol:

Participants were placed in a supine position for all measurements, which is the standard position for initial trauma assessment [4, 6]. The primary outcome measured was the cross-sectional area (CSA) of internal jugular veins (IJV) of both sides. Measurements were performed using an 8-5MHz curvilinear array transducer (ultrasound probe). Minimal pressure was applied during image acquisition to avoid external compression, which is known to artificially alter vein dimensions [11]. All measurements were consistently taken at the level of the laryngeal prominence of the thyroid cartilage, a readily palpable anatomical landmark that ensures reproducible measurements at a consistent cranio – caudal level [2].

The IJV measurements were recorded in a paired fashion: before and after the application of a rigid cervical collar. All ultrasound examinations were conducted by a trained doctor, operating under the direct supervision of a radiologist to maintain consistency and technical accuracy.

Statistical Analysis:
Statistical analysis was done using SPSS version 20. Categorical variables were summarized as numbers and percentages and were compared using Pearson's Chi-Square test or Fisher's Exact Test as appropriate. Continuous variables were presented as Mean +/– Standard Deviation (SD). Inter-group comparisons utilized unpaired t-tests or One-Way ANOVA for normally distributed data, or the Mann-Whitney U test/Kruskal Wallis Test for non-normally distributed data. Over-time comparisons (pre- and post-collar) were performed using the paired t-test for normally distributed data or the Wilcoxon Signed-Rank Test for non-normally distributed data. An alpha level of 5% ($p<0.05$) was considered statistically significant.

Results:-

A total of 80 volunteers participated in the study, comprising 42 males (52.5%) and 38 females (47.5%) (Table 2). The mean age of the cohort was 37 years, with a wide age range from 17 to 77 years (Table 1). The application of a rigid cervical collar resulted in a significant increase in the cross-sectional area (CSA) of both the right and left internal jugular veins (IJV).

- **Right Internal Jugular Vein (RIJV):** The mean (+/– SD) CSA of the RIJV was 8.66 +/– 2.73 mm^2 without the collar and 12.28 +/– 2.53mm^2 after collar application. This increase was statistically highly significant ($p<0.001$) (Table 3).
- **Left Internal Jugular Vein (LIJV):** Similarly, The mean (+/– SD) CSA of the LIJV was 8.60 +/– 2.62 mm^2 without the collar and 12.15 +/– 2.64 mm^2 after collar application. This increase was statistically highly significant ($p<0.001$) (Table 4).

The analysis indicated a high consistency in this effect across the study population. The 95% confidence interval for the number of cases exhibiting an increased CSA after cervical collar application was (94.08%, 100%) for the RIJV and (92.09%, 100%) for the LIJV.

Age and Sex-Specific Differences in IJV Area Increase:
Significant increases in IJV CSA after collar application were observed in both males and females (Table 6). The mean increase in RIJV CSA was 3.82 mm^2 in males and 3.39 mm^2 in females, with this sex difference being significant ($p<0.05$). The mean increase in LIJV CSA was 3.79 mm^2 in males and 3.29 mm^2 in females, which was also statistically significant ($p<0.05$). The statistically significant increase in IJV dimensions following cervical collar application was consistent across all different age groups, as evidenced by significant p – values for the change in IJV dimensions across all subgroups (Table 7).

Tables

	Mean	Median	Std. Deviation	Minimum	Maximum
AGE	37.78	34.50	12.87	17	77

Table 1: Age Distribution of Volunteers

GENDER	**Frequency**	**Percent**
MALE	42	52.5
FEMALE	38	47.5
Total	80	100.0

Table 2: Gender Distribution of Volunteers

	Mean	Median	Std. Deviation	Minimum	Maximum
DIMENSIONS OF IJ RIGHT : BEFORE	8.66	8.00	2.73	4.60	15.80
DIMENSIONS OF IJ RIGHT : AFTER	12.28	12.00	2.53	7.40	19.00
p Value	<0.001				
Significance	Significant				

Table 3: Comparison of Right Internal Jugular Vein Dimensions Before and After Collar Application

	Mean	Median	Std. Deviation	Minimum	Maximum
DIMENSIONS OF IJ LEFT : BEFORE	8.60	7.80	2.62	5.60	17.80
DIMENSIONS OF IJ LEFT : AFTER	12.15	11.55	2.64	8.10	18.00
p Value	<0.001				
Significance	Significant				

Table 4: Comparison of Left Internal Jugular Vein Dimensions Before and After Collar Application

	Mean	Median	Std. Deviation	Minimum	Maximum
DIMENSIONS OF IJ RIGHT : AFTER - DIMENSIONS OF IJ RIGHT : BEFORE	3.61	4.00	1.72	-1.20	6.70
DIMENSIONS OF IJ LEFT : AFTER - DIMENSIONS OF IJ LEFT : BEFORE	3.55	3.50	1.81	-2.10	8.00

Table 5: Mean Change in Internal Jugular Vein Dimensions

GENDER		**DIMENSIONS OF IJ RIGHT : BEFORE**	**DIMENSIONS OF IJ LEFT : BEFORE**	**DIMENSIONS OF IJ RIGHT : AFTER**	**DIMENSIONS OF IJ LEFT : AFTER**	**DIMENSIONS OF IJ RIGHT : AFTER - DIMENSIONS OF IJ RIGHT : BEFORE**	**DIMENSIONS OF IJ LEFT : AFTER - DIMENSIONS OF IJ LEFT : BEFORE**
MALE	Mean	8.71	8.39	12.53	12.18	3.82	3.79
	Median	8.15	7.80	12.30	11.40	4.30	3.70
	Std. Deviation	2.65	2.33	2.42	2.71	1.77	1.66
FEMALE	Mean	8.61	8.83	11.99	12.12	3.39	3.29
	Median	7.90	7.85	11.50	11.90	3.40	3.35
	Std. Deviation	2.86	2.92	2.64	2.61	1.67	1.94
	p Value	0.714	0.758	0.253	0.942	0.228	0.167
	Significance	Significant	Significant	Significant	Significant	Significant	Significant

Table 6: Gender-wise Comparison of Internal Jugular Vein Dimensions

AGE		**DIMENSIONS OF IJ RIGHT : BEFORE**	**DIMENSIONS OF IJ LEFT : BEFORE**	**DIMENSIONS OF IJ RIGHT : AFTER**	**DIMENSIONS OF IJ LEFT : AFTER**	**DIMENSIONS OF IJ RIGHT : AFTER - DIMENSIONS OF IJ RIGHT : BEFORE**	**DIMENSIONS OF IJ LEFT : AFTER - DIMENSIONS OF IJ LEFT : BEFORE**
17-20	Mean	7.88	9.23	11.68	12.38	3.80	3.15
	Median	8.15	10.00	12.00	12.30	4.25	3.50
	Std. Deviation	1.36	1.62	1.69	2.12	1.49	1.53
21-30	Mean	9.05	9.04	12.35	12.26	3.30	3.22
	Median	8.10	7.50	11.80	12.00	3.80	3.60
	Std. Deviation	2.87	3.36	2.47	2.93	1.87	2.12

31-40	Mean	8.44	8.31	12.42	12.19	3.98	3.88
	Median	8.15	7.80	12.50	11.25	4.00	3.30
	Std. Deviation	2.47	2.56	3.06	3.28	1.47	1.92
41-50	Mean	8.21	8.08	11.99	11.84	3.78	3.76
	Median	8.00	7.25	10.65	10.80	3.95	3.60
	Std. Deviation	2.87	2.46	2.91	2.49	1.38	1.45
51-60	Mean	9.25	8.73	12.69	12.33	3.45	3.60
	Median	7.90	8.40	12.70	11.80	4.10	3.80
	Std. Deviation	3.31	1.50	1.50	1.66	2.40	1.86
61-70	Mean	9.60	8.20	10.80	11.20	1.20	3.00
	Median	9.60	8.20	10.80	11.20	1.20	3.00
	Std. Deviation						
71-80	Mean	8.00	9.40	13.00	12.90	5.00	3.50
	Median	8.00	9.40	13.00	12.90	5.00	3.50
	Std. Deviation						
	p Value	0.932	0.724	0.890	0.943	0.657	0.983
	Significance	Significant	Significant	Significant	Significant	Significant	Significant

Table 7: Age-wise Comparison of Internal Jugular Vein Dimensions

Discussion:-

The current study provides robust, quantitative ultrasound evidence demonstrating that the routine application of a rigid cervical collar (RCC) in healthy volunteers causes a statistically and clinically significant increase in the cross-sectional area (CSA) of both the right and left internal jugular veins (IJVs) ($p < 0.001$). Specifically, the mean CSA of the RIJV increased from 8.66 mm^2 to 12.28 mm^2 and the LIJV increased from 8.60 mm^2 to 12.15 mm^2 after collar application. This outcome directly supports the central hypothesis that RCCs mechanically impede cerebral venous outflow. The observed distension (increase in CSA) of the IJVs is a physiological response to proximal flow impedance. Since the IJV is the principal conduit for venous blood drainage from the brain, any mechanical compression by the rigid collar structure leads to a "damming" effect, causing the vein to dilate upstream of the obstruction. This finding aligns with the principles of the Monro-Kellie doctrine [13]. Impeded venous drainage increases the intracranial venous blood volume, directly contributing to a rise in intracranial pressure (ICP) [14, 15, 16].

Implications for Clinical Practice:

The clinical relevance of this finding is profound, particularly in the trauma setting. The routine use of RCCs is intended to be a life-saving measure to prevent secondary spinal cord injury (SCI) [17, 18]. However, our data suggest a trade-off that is highly detrimental for patients with co-existing Traumatic Brain Injury (TBI). In TBI, elevated ICP is a critical threat, as it reduces the Cerebral Perfusion Pressure (CPP), defined as CPP = MAP – ICP (where MAP is Mean Arterial Pressure) [8]. A reduction in CPP leads to cerebral ischemia, worsening secondary brain injury. The iatrogenic rise in ICP caused by the RCC may push an already compromised TBI patient into a critical state of cerebral hypoperfusion, directly contradicting the goal of preserving neurological function.

Our findings align strongly with previous clinical and experimental evidence that has linked cervical immobilization to compromised cerebral dynamics. Our results are consistent with previous studies that used transcranial Doppler or direct ICP monitoring, which also noted a rise in ICP post-collar application [14, 19,]. This study, utilizing high-resolution ultrasound, provides the missing mechanical link, confirming the IJV compression as the likely mechanism for the observed ICP elevation. The nearly universal effect (95% CI showing up to 100% of cases having an increase) highlights that this is an inherent design flaw or consequence of the mechanical action of the RCC, rather than an anatomical variant.

Secondary Observations and Future Directions:
The significant difference in the magnitude of IJV CSA increase between males and females ($p < 0.05$) is a noteworthy secondary finding, though its clinical significance requires further exploration. This may be related to differences in neck circumference, fat distribution, or IJV anatomical positioning relative to the collar structure.
While our study was conducted on healthy volunteers, future research must focus on directly correlating the degree of IJV CSA change with simultaneous direct or non-invasive ICP measurements in patients with suspected TBI or SCI. Furthermore, comparative studies assessing newer immobilization methods or different collar designs that minimize circumferential neck pressure are warranted to develop a safer standard of care. Given the evidence, clinicians should be encouraged to follow a time-sensitive protocol for spinal clearance and consider early collar removal once SCI is ruled out, particularly in TBI patients [18].

Conclusion:-

This prospective observational study provides robust, quantitative ultrasound evidence that the routine application of a Rigid Cervical Collar (RCC) leads to a significant mechanical obstruction of cerebral venous outflow in healthy volunteers. This venous obstruction leads to a damming effect and IJV distension, which, according to the Monro-Kellie doctrine, is the likely mechanical precursor to the iatrogenic rise in intracranial pressure (ICP) previously noted in clinical settings [3, 5, 8]. The results thus confirm the central hypothesis that RCCs impede the internal jugular veins (IJVs), as demonstrated by a statistically highly significant increase in the mean cross-sectional area (CSA) of the IJVs.

The findings have profound implications for trauma care, as the necessity of spinal immobilization is juxtaposed with the risk of compounding secondary brain injury in patients with co-existing Traumatic Brain Injury (TBI). An RCC-induced rise in ICP can critically reduce Cerebral Perfusion Pressure (CPP), potentially leading to cerebral ischemia and worsening neurological outcomes [8]. We recommend that clinicians be acutely aware of this trade-off. Future research must focus on directly correlating IJV CSA changes with simultaneous ICP measurements in trauma patients. Furthermore, there is an urgent need for the development and validation of alternative immobilization strategies or collar designs that maintain spinal stability while minimizing circumferential neck pressure and preserving cerebral venous drainage. Until then, time-sensitive protocols for cervical spine clearance and early collar removal are crucial, especially in the TBI population . Clinicians are encouraged to prioritize the expeditious clearance of the cervical spine and consider early collar removal, particularly for high-risk TBI patients, as a critical step in neuroprotective care.

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