

## The Effect of the Valsalva Maneuver on the External Jugular Vein

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**Background:** The external jugular vein (EJV) is a useful intravenous (IV) cannulation site for anesthesiologists, although it has a relatively high failure rate. Unlike other central veins, visualization of the EJV is important during IV cannulation, and the Valsalva maneuver distends the jugular venous system. However, the relationship between the maneuver and EJV visibility remains unknown. This study compared EJV visibility before and after the Valsalva maneuver.

**Methods:** This was a prospective observational study that included 200 participants. After the induction of anesthesia, EJV visibility grade, depth from the skin to the EJV superficial surface (EJV depth), and EJV cross-sectional area (CSA) before the Valsalva maneuver were measured. The same parameters were measured after the Valsalva maneuver was performed. The EJV visibility grade was defined as grade A: good appearance and good palpation, grade B: poor appearance and good palpation, and grade C: poor appearance and poor palpation.

**Results:** Patient body mass index and EJV depth affected the EJV visibility grade before the Valsalva maneuver ( $p < 0.05$ ), although EJV CSA did not. The Valsalva maneuver distended EJV CSA and reduced EJV depth, although these changes were not correlated with EJV visibility grade. With regard to EJV visibility, 34.0% of grade B cases and 20.0% of grade C cases were improved by the Valsalva maneuver.

**Conclusions:** Although the Valsalva maneuver improved EJV CSA and EJV depth, it did not greatly affect EJV visibility grade.

**Key Words:** jugular veins; ultrasonography; Valsalva maneuver.

### Introduction

The external jugular vein (EJV) is a commonly used route for intravenous (IV) cannulation during general anesthesia. EJV cannulation is also indicated in the intensive care unit when massive and/or quick fluid administration or central venous pressure measurements are needed.[1,2] The EJV has many benefits compared to other IV routes, including the central veins, as it is easy to visualize (even during cardiac arrest), is located in a superficial location, and is relatively easy to access without imaging modalities.[1,3] However, the EJV route also has a relatively low success rate.[4] According to a few reports, the low

success rate of the EJV route is related to its poor visibility and anatomical variability, as well as the practitioner's technique.[5,6] To increase the success rate of EJV cannulation, many methods have been described, including distending the jugular venous system[7] and using ultrasound to visualize the EJV.[8-10] In addition, the Valsalva maneuver, Trendelenburg's position, and abdominal compression can dilate the EJV and provide a similar beneficial effect.[7,11] However,

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the primary outcomes in the previous studies were not the EJV's visibility, but rather the cross-sectional area (CSA) as measured via ultrasound.[12] Moreover, the factors related to the improved EJV visibility are not yet known.

We designed this prospective observational study to evaluate the hypothesis that distension of the EJV CSA using the Valsalva maneuver would improve the EJV visibility. Therefore, the study's primary objective was to compare the EJV visibility before and after the Valsalva maneuver in patients who were under general anesthesia. The secondary objectives were to compare the EJV CSA and depth from the skin to the superficial surface of the EJV (EJV depth) using ultrasonography before and after the Valsalva maneuver, and to evaluate the relationship between changes in EJV visibility grade and other variables.

## Materials and Methods

This prospective observational study was conducted between March 1, 2012 and August 31, 2012 in the operating room of a university hospital. The institutional review board approved the study's protocol, and all patients provided their written informed consent to participate in this study.

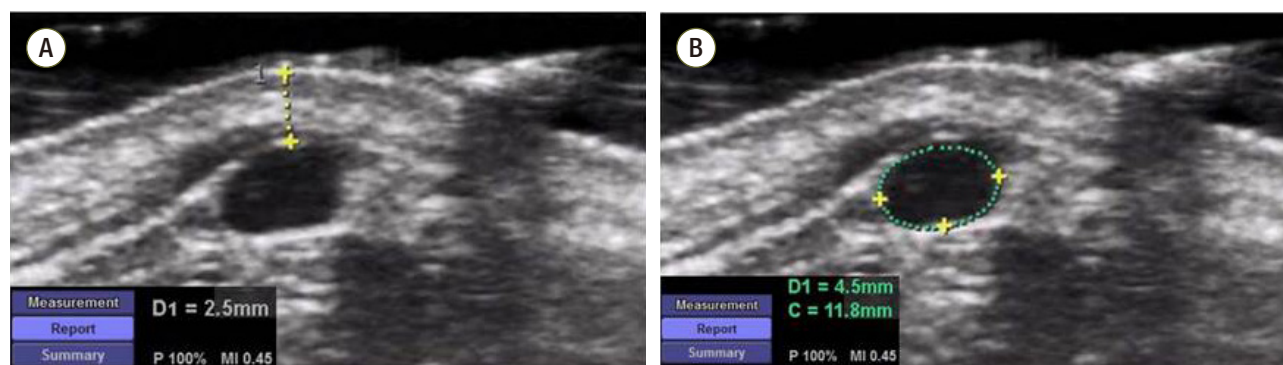
Two hundred participants were enrolled, and their medical history was taken at their enrollment. The inclusion criteria were patients who had an American Society of Anesthesiologists physical status classification of 1 or 2 and who were > 20 years old. The exclusion criteria included the presence of an abdominal mass, ascites, pregnancy, increased intracranial pressure, lung disease, previous neck surgery (cervical spine, thyroid, and ear, neck, or throat surgery),

neck mass, or perioperative hypotension.

Several variables such as sex, age, body mass index (BMI), EJV depth (Fig. 1A), and EJV CSA (Fig. 1B) were evaluated for their relationship with EJV visibility. EJV visibility was defined as grade A: good appearance and good palpation, grade B: poor appearance and good palpation, and grade C: poor appearance and poor palpation.

All patients were placed under general anesthesia, which was induced by propofol at 2 mg/kg, followed by tracheal intubation after intravenous administration of rocuronium at 0.6 mg/kg. Anesthesia was maintained by administration of 6-8 vol% desflurane and a fresh gas flow of 50% oxygen and air at 4 L/min. When the patient's hemodynamic values had stabilized after the induction of anesthesia, we evaluated the EJV visibility grade, EJV depth, and EJV CSA before and after the Valsalva maneuver using a portable ultrasound system (ACUSON X300, Siemens Medical Solutions, Malvern, PA, USA) with a 5-13 MHz linear transducer. The Valsalva maneuver in the pressure controlled-mode at a plateau airway pressure of 20 cmH<sub>2</sub>O was performed for 10 s.[13] The EJV visibility grade was evaluated by a single observer to reduce bias. The EJV CSA and EJV depth were measured three times at the cricothyroid membrane level, and the average of these values was used for the analysis. A thick layer of ultrasound gel was applied to prevent EJV compression.

The patient's blood pressure, heart rate, and airway pressure were recorded during the Valsalva maneuver to monitor for complications. In this clinical trial, we defined hypotension and bradycardia as a 20% reduction in the initial value. If hypotension or bradycardia occurred during the Valsalva maneuver, the procedure was stopped and the hypotension was managed by changing the patient's position and using



**Fig. 1.** External jugular vein cross-sectional area (A) and external jugular vein depth measured by ultrasonography (B). D1: depth of 1; C: circumference.

an appropriate vasopressor, such as ephedrine.

All data are presented as mean  $\pm$  standard deviation or number of patients (%). Demographics and baseline variables before the Valsalva maneuver were analyzed using the chi-square test or one-way analysis of variance with a post-hoc least significant difference test, as appropriate. Differences in the EJV visibility, EJV CSA, and EJV depth before and after the Valsalva maneuver were evaluated using paired t-tests. Pearson's correlation was used to evaluate the relationship between EJV depth before the Valsalva maneuver and other variables such as EJV CSA, BMI, and age. A simple logistic regression analysis was used to evaluate the relationship between improvements in the EJV visibility grade and the other variables. No missing patient data were discovered in this study. A p value of  $< 0.05$  was considered statistically significant, and all statistical analyses were performed using SAS for Windows (version 9.2, SAS Institute Inc., Cary, NC, USA).

## Results

Two hundred individuals were recruited for this study and complete data were collected for all participants (Fig. 2). The participants (115 women and 85 men) had an average age of  $50 \pm 17$  years, average weight of  $65.1 \pm 38.8$  kg, and an average height of  $160.0 \pm 10.0$  cm. The demographic and baseline data according to EJV visibility grade classification are presented in Table 1. BMI and the EJV depth before the Valsalva maneuver affected the EJV visibility grade before

the Valsalva maneuver, although the EJV CSA was not related to the EJV visibility grade. In addition, a positive correlation was observed between BMI and the EJV depth before the Valsalva maneuver ( $r = 0.27$ ,  $p < 0.001$ ).

The Valsalva maneuver significantly affected both the EJV CSA (Fig. 3A) and the EJV depth (Fig. 3B). After the Valsalva maneuver, the EJV CSA increased from  $0.16 \pm 0.17$  cm<sup>2</sup> to  $0.23 \pm 0.19$  cm<sup>2</sup> (35.6%), and the EJV depth decreased from  $2.74 \pm 1.18$  mm to  $2.42 \pm 1.06$  mm (10.7%). However, no significant changes were observed in the EJV visibility grade, as 34.0% of cases with grade B visibility and 20% of cases with grade C visibility exhibited an improved gross appearance after the Valsalva maneuver (Table 2). To analyze the factors that were associated with improvements in the EJV visibility grade after the Valsalva maneuver, we reviewed several variables, including age, BMI, EJV CSA before the Valsalva maneuver, changes in

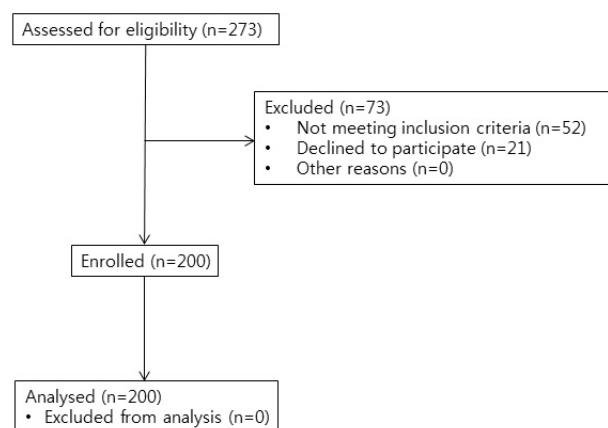


Fig. 2. Flow diagram of the patients.

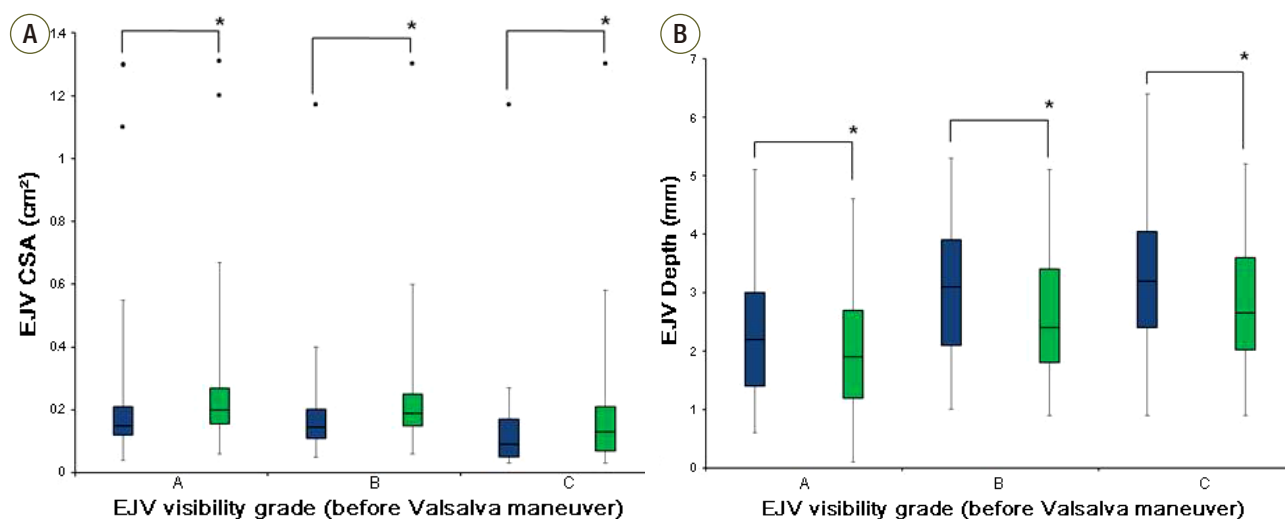
Table 1. Demographics and baseline variables before performance of the Valsalva maneuver

	Visibility grade A (n = 97)	Visibility grade B (n = 53)	Visibility grade C (n = 50)	p-value
Sex (M/F)	45/52	22/31	17/43	0.352
Age (years)	$52 \pm 18$	$45 \pm 15$	$50 \pm 17$	0.081
BMI (kg/m <sup>2</sup> )	$22.80 \pm 3.61$	$24.12 \pm 3.13^*$	$24.14 \pm 3.39^*$	0.025
EJV CSA (cm <sup>2</sup> )	$0.19 \pm 0.17$	$0.18 \pm 0.16$	$0.14 \pm 0.17$	0.159
EJV depth (mm)	$2.31 \pm 1.04$	$2.98 \pm 1.12^*$	$3.30 \pm 1.24^*$	$< 0.001$
MBP (mmHg)	$70.08 \pm 6.87$	$71.19 \pm 7.05$	$69.62 \pm 8.05$	0.517
HR (beats/min)	$72.88 \pm 11.15$	$73.84 \pm 11.05$	$73.09 \pm 11.33$	0.896

Values are mean  $\pm$  standard deviation or number of patients (%).

Visibility grade A: good appearance and good palpation, Visibility grade B: poor appearance and good palpation, Visibility grade C: poor appearance and poor palpation. M: male; F: female; BMI: body mass index; EJV: external jugular vein; CSA: cross-sectional area of external jugular vein; Depth: depth from the skin to the external jugular vein superficial surface; MBP: mean blood pressure; HR: heart rate.

\*p  $< 0.05$  vs. visibility grade A.



**Fig. 3.** Comparisons of external jugular vein cross-sectional area (A) and external jugular vein depth before and after the Valsalva maneuver at each EJV visibility grade (B). Visibility grade A: good appearance and good palpation of the EJV; visibility grade B: poor appearance and good palpation of the EJV; visibility grade C: poor appearance and poor palpation of the EJV. The blue-colored box represents EJV CSA or depth before the Valsalva maneuver, and the green-colored box represents EJV CSA or depth after the Valsalva maneuver. The box plot shows the median (solid line), interquartile ranges (box), and values within 1.5 interquartile ranges from each side of the box (whiskers). Outliers are indicated by solid circles. EJV: external jugular vein; CSA: cross-sectional area of the external jugular vein; EJV depth: depth from the skin to the external jugular vein superficial surface; \*p < 0.05 compared with EJV visibility before the Valsalva maneuver.

**Table 2.** External jugular vein visibility grade before and after the Valsalva maneuver

		Visibility grade								
Before the Valsalva maneuver		A			B			C		
Number		97			53			50		
After the Valsalva maneuver		A	B	C	A	B	C	A	B	C
Number (%)		97 (100.0)	0 (0.0)	0 (0.0)	18 (34.0)	34 (64.1)	1 (1.9)	1 (2.0)	9 (18.0)	40 (80.0)

Values are number of patients (%).

Visibility grade A: good appearance and good palpation, Visibility grade B: poor appearance and good palpation, Visibility grade C: poor appearance and poor palpation.

**Table 3.** Variables associated with improvements in external jugular vein visibility grade

Predictor variables	Odds ratio	95% confidence interval	p-value
Age	1.01	0.99 - 1.03	0.398
BMI	0.94	0.84 - 1.05	0.246
EJV CSA before the Valsalva maneuver	0.54	0.07 - 4.08	0.549
% changes in EJV CSA by Valsalva	1.01	1.00 - 1.02	0.109
EJV depth before the Valsalva maneuver	0.90	0.65 - 1.25	0.543
Changes in EJV depth by Valsalva	0.99	0.97 - 1.02	0.589

BMI: body mass index; EJV: external jugular vein; CSA: cross sectional area of external jugular vein.

the EJV CSA due to the Valsalva maneuver, EJV depth before the Valsalva maneuver, and changes in the EJV depth

due to the Valsalva maneuver. However, none of these factors were significantly associated with the EJV visibility grade (Table 3). During the Valsalva maneuver, no complications were observed, including hypotension and bradycardia.

## Discussion

After the Valsalva maneuver, the EJV CSA and EJV depth changed significantly (Fig. 3), although only 27.2% of the patients (visibility grade B and C) exhibited an improved visibility grade (Table 2). We were unable to identify any factors that were related to the change in EJV visibility grade (Table 3). In addition, even a significant change in the EJV depth after the Valsalva maneuver did not affect the

EJV visibility grade, unlike the initial EJV visibility grade (Table 1). We propose two possible explanations for these findings. First, the Valsalva maneuver that we performed may not have been sufficiently forceful to observe an improved EJV visibility grade. Second, unidentified patient factors, such as skin texture, thickness, or color, might be important, although we did not evaluate these factors in this study.

Central veins, including the internal jugular vein, subclavian vein, and femoral vein, are deep structures that are not visible. Therefore they can be cannulated using an anatomical landmark. However, the EJV is a superficial structure that is readily visible, and this visibility is an important factor in the successful cannulation of the EJV, unlike the other central veins.[2] There have been many studies to assess factors associated with success rate of central vein cannulation, including the EJV, and methods to increase the CSA of the central vein.[7,12,14-18] The Valsalva maneuver, abdominal compression, and the Trendelenburg position are common methods for improving venous distension. The Valsalva maneuver has been shown to increase the EJV CSA by  $136 \pm 23\%$  (95% confidence interval, 121.3-147.5%), and the Trendelenburg position has been shown to increase the EJV CSA by  $137 \pm 32\%$  (95% confidence interval, 120.7-156.9%).[7] These results are similar to ours, but EJV visibility was not considered in the previous study.

The Valsalva maneuver is performed using a forceful attempted exhalation against a closed glottis, leading to incremental increases in intrathoracic pressure and size of the extrathoracic veins, including the EJV.[14,19] Cardiovascular responses such as heart rate, blood pressure, stroke volume, and venous return, differ with various strain pressures in the Valsalva maneuver.[19] In this clinical trial, we successfully applied a low strain pressure and short duration for the Valsalva maneuver to avoid any cardiovascular complications. [13,19]

Several limitations of this study should be considered when interpreting the results. First, actual cannulation of the EJV was not performed in this study, and we only evaluated various factors that might have been linked to the EJV's gross appearance. Second, although the EJV depth was associated with the visibility grade before the Valsalva maneuver (Table 1), and subsequently decreased after the Valsalva maneuver (Fig. 3B), the actual change in the visibility grade

was minimal (Table 2). Therefore, we cannot comment on the magnitude of in the EJV depth that is needed to improve the visibility grade. Third, only one observer evaluated EJV visibility in this study. Although it is good to increase inter-observer reliability, this practice could also have caused bias in the intra-observer reliability. Further studies should incorporate EJV cannulation before and after the Valsalva maneuver. In addition, the success rate of EJV cannulation by the visibility grade should also be explored.

In conclusion, although the Valsalva maneuver increased the EJV CSA and decreased the EJV depth, it did not greatly improve the EJV's visibility.

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