

## Long versus Short Axis ultrasound guided approach for internal jugular vein cannulation: a prospective randomised controlled trial

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### Abstract

**Aim:** The aim of this study was to compare the short and long axis approaches to ultrasound guided right internal jugular vein cannulation with respect to indicators of success. **Methods:** Patients undergoing cardiac surgery requiring central venous cannulation (99 patients) were randomised to undergo either long or short axis ultrasound guided cannulation of the right internal jugular vein by a skilled anaesthetist. First pass success, number of needle passes, procedural time and complications were documented for each procedure. **Results:** The right internal jugular vein was successfully cannulated in all 99 patients. The first pass success rate was significantly higher in the short axis 98% group compared to the long axis group 78% [48:1 (98%) versus 39:11 (78%)  $p < 0.006$ ]. Procedural time was comparable in both the groups [39.6 (18.4) versus 46.9 (42.4)]. Fewer needle redirections were required in the short axis group [1.02 (0.02) versus 1.24 (0.56)  $p < 0.004$ ]. Carotid artery puncture only occurred in the long axis group. **Conclusions:** We conclude that anaesthetists with experience in ultrasound guided internal jugular vein cannulation, have higher first pass success rate and less carotid artery puncture when a short axis, rather than a long axis, approach is employed.

**Keywords:** internal jugular vein, ultrasound, venous cannulation, scanning axis

### Rezumat

**Scopul studiului:** Compararea ratei de succes a cateterizării în ax lung și în ax scurt a venei jugulare interne prin ghidaj ecografic. **Metode:** Au fost randomizați 99 de pacienți supuși unor intervenții chirurgicale cardiovasculare ce necesitau montarea unui cateter central; acestora li s-a montat un cateter la nivelul venei jugulare interne drepte de către un anestezist cu experiență, prin ghidaj ecografic, folosind abordul vascular în axul lung sau în cel scurt. Reușita la prima tentativă, numărul de redirectionări ale acului, timpul necesar precum și complicațiile survenite au fost documentate pentru fiecare dintre cele două proceduri. **Rezultate:** Vena jugulară internă dreaptă a fost cateterizată cu succes la toți cei 99 de pacienți. Succesul de la prima tentativă a fost semnificativ mai mare la grupul cu abord în ax scurt 98%, prin comparație cu grupul cu abord în ax lung 78% [48:1 (98%) versus 39:11 (78%)  $p < 0.006$ ]. Timpul procedurii a fost similar în ambele grupuri [39.6 (18.4) versus 46.9 (42.4)]. Un număr mai mic de redirectionări ale acului au fost necesare în grupul cu abord în ax scurt [1.02 (0.02) versus 1.24 (0.56)  $p < 0.004$ ]. Puncționarea accidentală a arterei carotide a survenit doar la grupul cu abord în ax lung. **Concluzii:** Anestezistii cu experiență în cateterizarea venei jugulare interne prin ghidaj ecografic au o rată mai mare a succesului de la prima tentativă și un număr mai mic de puncționări ale arterei carotide atunci când folosesc abordul în ax scurt.

**Cuvinte cheie:** vena jugulară internă, ecografie, canulare venoasă, plan de examinare

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### Introduction

Cannulation of the internal jugular vein is a procedure commonly performed by anaesthetists. Traditionally, a blind surface landmark-guided technique has been used. This approach has a reported first pass failure rate of 31% [1,2] arterial puncture rate of 5% and over all complication rates of 40% [3]. The most common complications are bleeding, haematoma, arterial puncture, pneumotho-

rax [4,5]. Less commonly damage to neural structures such as the stellate ganglion, phrenic nerve and the brachial plexus has been reported [6-9].

Ultrasound techniques were first reported for internal jugular vein cannulation in 1984 [10]. The development of portable lightweight ultrasound machines, designed specifically for central venous cannulation, has made ultrasound guidance practical for routine clinical use. Ultrasound facilitates direct visualisation of the internal jugular vein, its dimensions, orientation, and surrounding structures resulting in improved first pass success rates, reduced number of needle passes and less inadvertent injury to surrounding structures [11]. The National Institute for Clinical Excellence (NICE) published guidelines supporting the routine use of ultrasound guidance for internal jugular vein cannulation [12].

Ultrasound imaging of the internal jugular vein may be orientated along either short axis (cross-sectional view) or long axis (longitudinal view). It is not known which scanning axis provides the optimal conditions for vascular access. The objective of this study is to compare ultrasound guided short versus long axis cannulation of the right internal jugular vein with respect to first pass success rate, the number of needle passes and the rate of arterial puncture.

## Methods

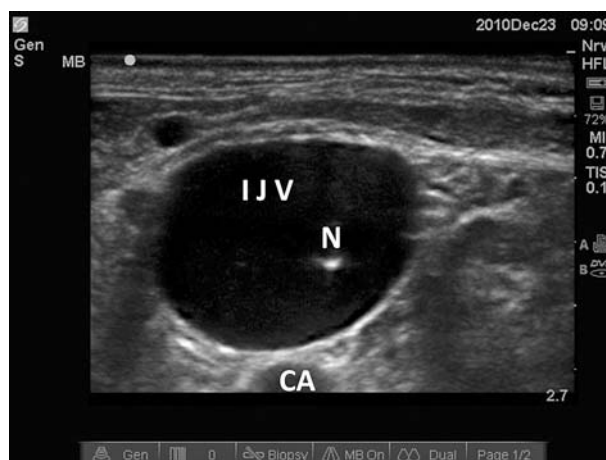
The study was approved by the Cork Teaching Hospitals Research Ethics Committee. Adult subjects presenting for elective cardiac surgery were approached the day before scheduled surgery and written informed consent obtained. Patients were randomised by computer generated random number tables, to one of two groups. Group A: Short axis ultrasound guided approach. Group B: Long axis ultrasound guided approach.

All patients had central venous cannulation of the right internal jugular performed using the "Seldinger" technique. Following induction of general anaesthesia, subjects were placed in a head down position with the head turned to the left. The skin of the anterior and lateral neck was prepared using antiseptic solution and draped. The ultrasound probe used was a 6-10 L38 MHz linear transducer SonoSite Titan unit (SonoSite®, Micromaxx, Bothwell, WA, USA). The probe was covered with a sterile sheath and sterile ultrasound gel was applied to both the inside and outside of the sheath. Each cannulation was performed by one of two anaesthetists with experience of more than 50 ultrasound guided internal jugular cannulations. An observer unskilled in ultrasound guidance who was unaware of the group allocation observed the procedure and recorded the following information: patient demographics, first pass success, number of needle passes (defined as the number of times

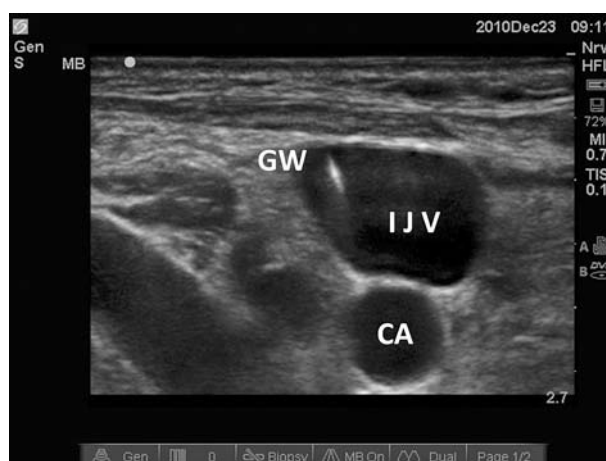
the needle was withdrawn and redirected), time taken to insert the guidewire (defined as the time from the first needle insertion to ultrasound confirmation of presence of the guidewire within the vein); and carotid artery puncture rate.

### Short Axis Technique

An axial (cross-sectional) image of the internal jugular vein was obtained by placing the transducer in a transverse orientation on the patient's neck at the level of the cricoid cartilage. The needle was inserted at 60° to the vertical and advanced toward the vein employing gentle aspiration on the attached syringe. Entry to the vein was confirmed by visualising indentation of the anterior wall of the vein followed by blood in the syringe (fig 1). Confirmation of guidewire placement in the internal jugular was performed by rescanning the vein in a short axis plane (fig 2).



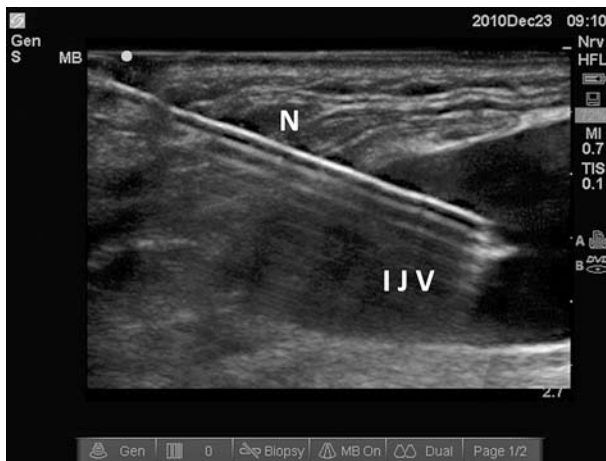
**Fig 1.** Short axis views of the internal jugular vein and surrounding structures in the anterior neck. IJV = Internal Jugular Vein; CA = Carotid Artery; N = Needle.



**Fig 2.** Short axis views of the internal jugular vein and surrounding structures in the anterior neck. IJV = Internal Jugular Vein; CA = Carotid Artery; GW = Guide Wire.

*Long Axis Technique*

An axial (short axis) view was first obtained. The probe was centred on the internal jugular vein and rotated through 90° in a clockwise direction resulting in a long axis image of the vein. The needle insertion point was directly beneath the most proximal end of the ultrasound probe. The needle was inserted at 30° to the vertical and advanced toward the vein employing gentle aspiration. Entry to the vein was confirmed by visualising needle entry into the vein (fig 3) followed by aspiration of blood in the syringe. Confirmation of guidewire placement was performed by rescanning the vein in both long and short axes (fig 4).



**Fig 3.** Long axis views of the internal jugular vein and surrounding structures in the anterior neck. IJV = Internal Jugular Vein; N = Needle.



**Fig 4.** Long axis views of the internal jugular vein and surrounding structures in the anterior neck. IJV = Internal Jugular Vein; GW = Guide Wire.

*Statistical Analysis*

Results were analyzed on an intention-to-treat basis using EpiInfo™ 2002 (Centers for Disease Control and Prevention, USA) statistics software. Normally distributed continuous data were analyzed using the unpaired Student *t* test for samples of unequal variance or a one sided ANOVA as appropriate. Non-normally distributed data were analyzed using the non-parametric Mann–Whitney/Wilcoxon two-sample test. Differences in proportions were compared by Yates Chi-square test. Statistical significance was considered at  $p < 0.05$ .

**Results**

Patient characteristics and clinical data are summarized in Table I. There are no significant differences between the two groups in terms of gender, age and weight ratio. Whilst the right internal jugular vein were successfully cannulated in all 99 patients, the first pass success rate was significantly higher in the short axis group comparing to the long axis group [48:1 (98%) versus 39:11 (78%)  $p < 0.006$ ]. The time taken for cannulation was comparable in both the groups [39.6 (18.4) versus 46.9 (42.4)]. The number of needle passes was significantly lesser in the short axis group when compared to the long axis group [1.02 (0.02) versus 1.24 (0.56)  $p < 0.004$ ]. In addition, Whilst there was no statistical significance, a definite trend was observed towards more carotid artery puncture with long axis view comparing short axis view (49:0 versus 48:2  $p < 0.48$ ).

**Discussion**

Ultrasound-guided internal jugular vein cannulation can be performed using two approaches: short axis-needle out-of-plane or long axis needle-in-plane. There are advantages and disadvantages to each approach. In the short axis approach, both the artery and vein can be seen simultaneously viewed and minimal probe adjustment is required. However, during cannulation the needle may not be seen as it is advanced out of the scanning plane. Therefore needle tip location is based on visualisation of tissue movement and educated guess work. With the long axis view, however, the operator advances the needle in the long axis of the scanning beam and can visualise the entire length of the needle as it punctures the target vessel. Although needle visualisation is improved, the acquisition of the long axis image of the internal jugular vein is technically more difficult than the short axis view. Using the long axis view, information regarding the location of the carotid artery relative to the internal jugular vein may be lost. Therefore correct identification of the single vessel in the scanning field is essential.

Table I. Demographics and clinical characteristics. Values are mean (SD) or absolute numbers

| Variables                               | Short axis<br>(n=49) | Long axis<br>(n=50) | P-value            |
|---|----------------------|---------------------|--------------------|
| Gender (M:F)                            | 37:12                | 37:13               | 0.95 <sup>+</sup>  |
| Age (years)                             | 62.9 (13.2)          | 62.9 (13.1)         | 0.98*              |
| Weight (kg)                             | 85.2 (13.5)          | 84.1 (15.7)         | 0.69*              |
| Number of Needle Passes                 | 1.02 (0.02)          | 1.24 (0.56)         | 0.004 <sup>#</sup> |
| Proportion 1 <sup>st</sup> pass success | 48:1 (98%)           | 39:11 (78%)         | 0.006 <sup>+</sup> |
| Time in seconds                         | 39.6 (18.4)          | 46.9 (42.4)         | 0.59 <sup>#</sup>  |
| Arterial Puncture                       | 49:0                 | 48:2 (4%)           | 0.48 <sup>+</sup>  |

+ = Yates Chi-square test, 2-tailed

\* = ANOVA

# = Mann-Whitney/Wilcoxon two-sample test

Our study compared the short axis approach to the long axis approach for right internal jugular vein cannulation in patients scheduled for cardiothoracic surgery. We found that the number of needle passes was significantly lower and the first pass success rate was significantly higher in the short axis view when compared to the long axis view. In 98% of patients in the short axis group, the right internal jugular vein was cannulated on first needle pass. Our results compare favourably with Schummer *et al* [13] who reported similar first pass success rate (96.6%) using a short axis approach. The single remaining patient (1/49 patients) was successfully cannulated on the second needle pass. This patient had torticollis with a short neck where neck movement was limited and probe placement was difficult. In the long axis group 78% of patients had their internal jugular vein cannulated on the first needle pass. For the remaining patients in the long-axis group, cannulation was successful on the second needle pass. In both groups the rate of successful internal jugular vein cannulation rate was 100% with one needle redirection (at the second needle pass).

Ours is the first study to compare the short axis versus long axis view for internal jugular vein cannulation in humans. Blaivas *et al* did a similar study using inanimate models where they found that novice ultrasound users obtain vascular access faster (The mean times to vein cannulation in short axis versus to long axis were 2.36 minutes and 5.02 minutes) with a short axis approach [14]. In our study we did not find any significant difference in time taken for cannulation in two approaches. The time taken to confirm the placement of guide wire was 39.6 ± 18.4 seconds versus 46.9 ± 42.4 seconds in short axis and long axis. The difference between our study and Blavais *et al* may be attributed to the involve-

ment of experienced operators.

In our study there is a significant difference in first pass unsuccessful rate in short versus long axis approach (2% versus 22%). In addition to that 4% of patients in the long axis group had inadvertent arterial puncture. This could be due to various reasons. The cannulation may be easier with less or no arterial puncture if both the vein and artery are seen simultaneously on the screen as in short axis view. The operators in our study have less experience in long axis cannulation than short axis cannulation because the long axis cannulation needs more hand eye coordination and alignment of the probe than short axis approach. Future research may explore the role of novel technology such as 3/4D imaging may facilitate advances in ultrasound-guided vascular access [15].

Our study has a number of important limitations. Those performing vascular access in the study were experienced anaesthetists. Therefore the data obtained may only be extrapolated to anaesthetists experienced in ultrasound-guided central venous access. Assumptions cannot be made as to the superiority of otherwise of the short axis technique in terms of higher success at first pass in the hands of novices. We did not collect data pertaining to the total time taken to perform vascular access to include all steps in the process. This was a weakness in initial study design. As image acquisition for the long axis approach involves an additional series of actions, it may have been useful record this time data.

**In conclusion**, in the hands of anaesthetists with experience of a minimum of 50 ultrasound-guided internal jugular vein cannulations, first pass success is increased and carotid artery puncture reduced when a short axis approach is employed.

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**Conflicts of interest:** none

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