Evaluation of Surface Landmarks and C-Length as Predictors of the Depth of Right Internal Jugular Venous Catheter Insertion:

A Transesophageal Echocardiography-Guided Study

Thesis

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List of Abbreviations

Abb.	Full term
ASA	*American Society of Anesthesiologists*
CRS	*Catheter related sepsis*
CVC	*Central venous catheter*
CVP	*Central venous pressure*
CXR	*Chest x-ray*
ECG	*Electrocardiogram*
FDA	*Food and drug administration*
IJV	*Internal jugular vein*
PA	*Postero-anterior*
RA	*Right atrium*
RA-SVC	*Right atrium-superior vena cava*
SCV	*Subclavian vein*
SVC	*Superior vena cava*
T_1	*Transverse process 1*
TEE	*Transesophageal echocardiography*
US	*Ultrasound*

INTRODUCTION

Central venous catheterization is a standard clinical practice for infusion of fluids, blood products, or vasoactive drugs into the central circulation or for monitoring central venous pressure during perioperative periods. However, this procedure can lead to significant complications including cardiac arrhythmia, vascular injury, hydrothorax, hemothorax, hydromediastinum or cardiac tamponade.[1-3] Such complications can occur when the catheter tip is inserted within the heart chambers or when it abuts the vascular wall at a steep angle.[4]

Although optimal positioning of the catheter tip is controversial depending on the duration of the use (short-term or long-term) and indication for insertion, the US Food and Drug Administration has stated that the catheter tip should not be located in or allowed to migrate into the heart.[5] If the running direction of the catheter is not parallel to the long axis of the superior vena cava (SVC), the vascular wall can be eroded by touching the tip of the catheter. In addition, venous thrombosis and misplacement of the catheter in the left brachiocephalic vein or small collateral vessels, such as the azygous vein are possible if the CVC is placed the upper or middle SVC.[6,7]

To prevent these risks and to ensure proper hemodynamic monitoring, the catheter tip should be placed in the lower SVC, near the junction of the right atrium and the

SVC (RA–SVC junction).[4,5] The lower SVC, near the RA–SVC junction, might be the optimal position of the catheter tip for monitoring and administration of vasoactive drugs during perioperative periods and for preventing malfunction, migration, and thrombosis.

The method introduced by Lee and Lee[8] using two radiographic landmarks on the PA CXR for identifying the length at which the tip of the CVC should stand in the mid-SVC have shown remarkable results; these landmarks are the edge of the right transverse process of the first thoracic spine (T1) and the center of the carina (C). The distance between these two points is termed the C-length. In this method AP CXRs preceding the operation were taken and assessed for the initial measurements of the C-length.[8]

In 2003, Hakim[9] described a method based completely on surface landmarks for determination of the depth of CVC by adding the distance between the right sternoclavicular joint and the lower border of 2nd rib on the right side to the distance between the insertion point and right sternoclavicular joint. The target was to place the catheter tip outside the pericardium, at the mid-SCV. This target point is 3 cm above the SVC-RA junction. [13] This would ensure placement of the CVC outside the pericardial reflection, a recommendation that has been called for in order to reduce the risk of cardiac tamponade.[11]

AIM OF THE WORK

The primary aim of the current study is to examine the accuracy of the C-distance or surface landmarks in determining the length of CVC that is required to place the catheter tip at the mid-SCV as confirmed by transesophageal echocardiography (TEE). A secondary aim is to derive an equation or formula to calculate the depth of the CVC that is required in order to have the catheter tip placed at the mid-SVC.

Chapter 1

CENTRAL VENOUS CATHETERIZATION

Central venous catheterization (CVCs) is a standard clinical practice for infusion of fluids, blood products, or vasoactive drugs into the central circulation or for monitoring of central venous pressure (CVP) during the perioperative period in hemodynamically unstable patients and those undergoing major operations.[1]

CVCs are commonly inserted into the internal jugular, subclavian or femoral veins on either side. Incorrect positioning of catheter tip may give false CVP readings leading to incorrect volume replacement and cause other serious complications such as vascular laceration, hemothorax, hydrothorax, pneumothorax arrhythmias, placement in the coronary sinus, tricuspid valve damage, thromboemboli, infection, nerve damage, pressure on the airway by hematoma, tracheal injury ,cardiac tamponade or death.[1-4,11]

Complications of central venous catheter malpositioning:

Perforation:

Perforation is thought to occur from mechanical trauma of catheter tip or from chemical damage of infused solutions, it has been widely reported and may result in pleural effusion, hydrothorax, haemothorax, pneumothorax, or pneumomediastinum. Cardiac tamponade has been reported also and this is explained by the finding by Schuster and colleages[10] that the pericardium may ascend alongside the medial wall of SVC by up to 5 cm (mean 3 cm). Thus placement just proximal to the atrium does not obviate the risk of tamponade. [4]

Thrombosis and catheter related sepsis:

Thrombosis occurs where there has been repeated trauma to the endothelium from the catheter tip. There is increasing evidence of a relationship between shallow placement of the catheter tip and thrombosis. Catheter related sepsis (CRS) is a major problem with a direct mortality rate of 25%. A clear relationship has been established between CRS and thrombosis and the combination of both can result in devastating septic thrombophelebitis.[11]

In conclusion optimally, the catheter tip should be placed in a large vein, ideally outside the heart and parallel with the long axis of the vein such that the tip does not abut the vein or heart wall.[4]

- **Anatomy of Superior vena cava:**

The superior vena cava is located within the superior and middle mediastinum.

The right and left brachiocephalic veins formed by the union of the internal jugular vein (IJV) and the subclavian vein (SCV), join to form the superior vena cava posterior to the inferior border of the first right costal cartilage space Fig(1). The superior vena cava descends downwards vertically, running posterior to the second and third intercostal spaces. The lower portion of the superior vena cava is covered by thin fibrous pericardium. The superior vena cava terminates in the superior and posterior portion of the sinus venarum of the right atrium. There are no valves present at the point at which the superior vena cava drains into the right atrium. The superior vena cava is approximately 7 centimeters in length and 2 cm wide.[12]

In a study by Albrecht and colleagues[13] in which they examined fresh cadavers 48 hours post-mortem they found out that the pericardium was fixed to the medial wall of the SVC up to the beginning of the aortic arch, near to the brachiocephalic trunk. The intrapericardial part of the SVC (A in Fig. 2) was 5.3 cm to 8.0 cm (range 3 cm).

The length of the medial side of the SVC, fused with the pericardium (B in Fig. 2), was 3.4(±0.2) range 1.4 to 5.5

cm.The carina was located at a distance of 0.8 (±0.05) range 0.3 to 1.5 cm above the pericardial reflection (C in Fig. 2). In no case was the carina located below the pericardial duplication on the medial side of the SVC.[13]

- **External Anatomical landmarks of Superior vena cava:**

The brachiocephalic veins can be projected onto the surface as broad bands 1.5 cm wide from the sternal end of the clavicle on each side to the formation of the SVC at the lower border of the first right costal cartilage. The SVC is 7cm in length and 2 cm wide and partially behind the right margin of the sternum; it extends from the lower border of the first right costal cartilage to the lower border of the third right costal cartilage. The angle of Louis can be palpated easily near the second rib insertion to the manubriosternal joint. So the middle SVC zone is considered to be at the level of the lower border of the right second costal cartilage. [14,15]

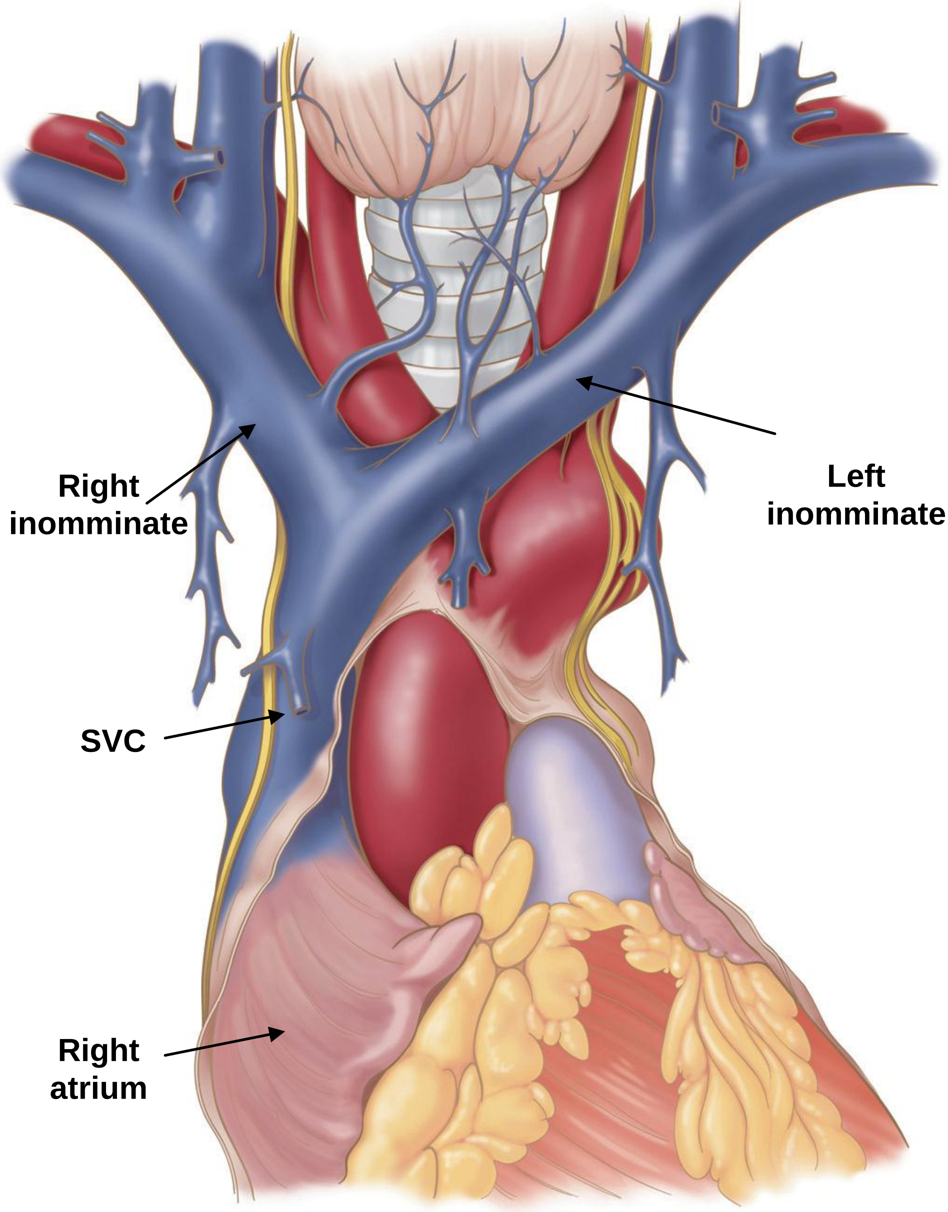

Figure 1: Formation of Superior vena cava Bennet et al [15].