Electrocardiographic-Guided Technique for Placement of Ventriculoatrial Shunts: A Valid and Cost-Effective Technical Simplification

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BACKGROUND: **Ventriculoatrial (VA) shunt is a routine technique for the treatment of hydrocephalus. The correct position at the superior vena cava—right atrium junction is generally assessed by radiography. We present the first experience of an alternative, nonradiographic technique to assess the distal end of the VA shunts through an electrocardiographic (EKG) method. The technique has developed from the large experience of central venous catheters (CVC) worldwide; the EKG-guided method is a common and validated alternative to standard radiologic control of the location of the tip of any CVC.**

METHODS: **Five consecutive patients underwent VA shunt with venous catheter positioned with the EKG-guided technique. The position of the catheter tip was verified by standard chest radiography.**

RESULTS: **Four men and 1 woman (mean age, 45.4 years) underwent VA shunt for hydrocephalus with the EKG-guided technique. The side of internal jugular vein puncture was the right side in 4 cases and the left side in 1 case. As confirmed by radiography, all VA shunt tips were located within the correct range. There was no radiologic evidence of procedure-related complication or catheters that had to be replaced.**

CONCLUSIONS: **The EKG-guided technique for VA shunts is as accurate as fluoroscopy, but simpler, more readily available, less expensive, safer, and more cost effective. It reduces the need of radiography and radiologic exposition for both patients and operators. The EKG method may be a valid and cost-effective alternative to standard radiologic control in VA shunts, as for any central venous access device, and could become the preferential method for confirming tip position during VA shunt surgery.**

INTRODUCTION

Ventriculoatrial (VA) shunt is a routine technique regularly used worldwide for the treatment of hydrocephalus.[1] Even although it is rarely a first-line option, because most cases are treated with endoscopic techniques[2] or with a ventriculoperitoneal shunt, VA is still a valid alternative in cases of failure of previous surgery.[3]

In the standard technique, the shunt is connected to a catheter inserted into the venous system through the echographic-guided puncture of the internal jugular vein (IJV). Assessing the correct position of the venous catheter is essential to avoid serious complications such as perforation, migration, thrombosis, or dysrhythmia caused by interactions of venous catheters with the vessel wall or the endocardium.[3] The correct position of the catheter tip is considered to be in the lower third of the superior vena cava (SVC) close to its entrance to the right atrium (RA) where blood flow conditions are optimal to keep the catheter away from the intima and to dilute cerebrospinal fluid into blood flow immediately. Because of the risk of malposition, the most common technique to control catheter position is by intraoperative radiographic assessment.[1,3]

Key words
- CVC placement
- ECG-guided technique
- EKG-guided technique
- Hydrocephalus
- VA shunt
- Ventriculoatrial shunt
- Ventriculoperitoneal shunt
- VP shunt

Abbreviations and Acronyms
CVC: Central venous catheter
EKG: Electrocardiographic
IJV: Internal jugular vein
RA: Right atrium
SVC: Superior vena cava
VA: Ventriculoatrial

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We herein present the first experience in the literature that proposes an alternative, nonradiographic technique to establish the distal end of VA shunts through an electrocardiographic (EKG)-guided method; this technique is developed from the large experience of central venous catheters (CVCs) worldwide.

The EKG-guided method is a common alternative to the standard radiologic control of the location of the tip of any central venous access device and it is rapidly becoming the preferential method for confirming the tip position during any kind of CVC insertion.[4] The experience in the literature on this topic is large and many CVCs are routinely positioned with this method.[4,5]

The purpose of this study is to evaluate feasibility, safety, and effectiveness of the EKG-guided method in positioning the distal end of VA shunts.

METHODS

Approval was obtained by the Catholic University of Rome institutional review board, and all patients provided informed consent for this study.

Patients between 18 and 80 years of age requiring a VA shunt between January 2016 and January 2017 were enrolled in the study. Exclusion criteria were presence of a nonsinus rhythm, pregnancy, current incarceration, or known anatomic abnormality of the central venous system.

All patients received verification of tip placement with both EKG and radiologic confirmation. Optimal position was considered to be the inferior third of the SVC as close as possible to its junction with the RA; after EKG-guided placement, the desired position was verified with intraoperative chest radiography and the distance of the catheter tip from the SVC-RA was recorded for each case.

Distal portions of VA catheters used in the study were all open-ended (Codman Hakim-Medos programmable valve, DePuy Synthes, Jhonson & Jhonson USA) catheters.

Steps for Placing EKG-Guided VA Shunt

The EKG-guided VA catheter positioning technique is the same as that used for the positioning of central and peripheral venous catheters (saline column technique) and can be applied with both open-ended or close-ended shunts.

This technique is based on the principle that if an endocavitary electrode, which is integrated with the atrial-ventricular catheter prefilled with saline, is advanced into the venous system, from the IJV (echo-directed) to the heart, changes in the P-wave on the EKG trace can be detected.

As the tip of the catheter approaches the heart, the P-wave increases progressively in amplitude until it reaches a peak of amplitude and then decreases again until it becomes negative when it moves away from the heart to the inferior vena cava (**Figure 1**).

Description of the Technique

1) IJV puncture with standard ultrasound-guided modified Seldinger technique using a standard CVC set with a peel-away introducer. CVC catheter is removed and the distal portion of the shunt is inserted.
2) Prefill the shunt catheter with saline and attach a steel needle (a normal needle from a syringe) (**Figure 2A**). Attach a sterile EKG alligator cable to the needle, carefully punching the tip of the grabber (**Figure 2B**) (alternatively, a sterile sleeve covering the connection can be used). The saline solution within the catheter transmits the EKG signal to the needle and hence to the EKG monitor. The signal is amplified by an amplifier connected to the alligator cable (**Figure 2C**). A normal P-wave should appear on the anesthesiologist's EKG monitor (**Figure 1A**).
3) The catheter is advanced to the RA: a biphasic P-wave should appear on the monitor. The negative P-wave is normal size initially, increasing in amplitude as the catheter is advanced (**Figure 1B**).
4) At this point, we know that the catheter tip is in the RA; the catheter can be then retracted until a positive P-wave is evident.
5) When the positive P-wave is fully peaked or at the highest amplitude, the catheter tip is at the caval/atrial junction (SVC-RA). This is the final position of the catheter (**Figure 1C**).
6) The distal portion of the shunt is connected to the cranial part of the shunt.

If no QRS pattern is seen during advancement of the catheter, the catheter is malpositioned in the IJV or in the contralateral subclavian vein. Attempts to reposition can be made until the inverted QRS is seen on the monitor.

RESULTS

From January 2016 to January 2017, 5 consecutive patients underwent VA shunt for chronic hydrocephalus with the EKG-guided technique. Patients characteristics and radiologic assessment of shunt position are summarized in **Table 1**.

Mean age at surgery was 45.4 (±16.7) years (4 men and 1 woman). The side of IJV puncture was the right side in 4 patients and the left side in 1 patient. In all patients, a history of previous ventriculoperitoneal shunt malfunctions was present. In 2 patients, chronic hydrocephalus was congenital; in 1 patient, it was secondary to subarachnoid hemorrhage; in 1 patient, it was secondary to subarachnoid hemorrhage and cerebrospinal fluid infection; and in 1 patient, it was idiopathic.

For each catheter, the correct position of the line tip was confirmed on chest radiography performed intraoperatively. The correct position of the catheter at the SVC-RA junction was considered at the junction between the first and second right cardiac arch, and from 1 to 3 cm from the carina according to the standard radiologic criteria.[6]

The catheter distance from radiographic projection of the SVC-RA junction was an average of 2.4 (±1.1) mm, taking into account the distance of the shunt tip from the first to the second cardiac arch intersection and 22.2 (±4.1) mm from the carina; all catheter tips were thus located within the correct range (**Figure 3**). There was no radiologic evidence of any procedure-related complication and no catheter had to be replaced.