CVC placement in post-COVID-19 era, a renaissance of ECG tip positioning technique

Mauro Pittiruti, Catholic University Hospital, Rome (Italy)
This story begins a long time ago....

Intracavitary electrocardiography for tip location during central venous catheterization: A narrative review of 70 years of clinical studies

Mauro Pittiruti, Filippo Pelagatti and Fulvio Pinelli
1949: The beginning
17078. Recording of Intracavity Potentials Through a Single Lumen, Saline Filled Cardiac Catheter.


From the Department of Medicine, Lakeside Hospital, Western Reserve University School of Medicine, Cleveland, Ohio.

* Fellow of the National Institute of Health.
(a) Rubber stopper modified to insert into arm end of catheter (b). (c) Is metal syringe adapter with rubber center core. Through each adapter a German silver wire is passed to project 2-4 cm. into the saline filled lumen of the arm end of the catheter. Exploring terminal of ECG is connected to battery clip.
The study identified the possibility of recording intracavitary potentials using a catheter filled with saline.

Electrical connection was achieved by the ‘saline column’ method (in a previous 1948 report from Kisch et al., a thin wire inside the catheter had been used).

No mention of the possibility of using this method for tip location
1981-2003: Prehistory

[Central venous catheterization using ECG monitoring and its obstetrical application (author's transl)].

[Article in Japanese]
Ohta C, Ohkusa T, Tamada T.


[Control of the position of central venous catheters by intracardial ECG. A presentation of the method and its advantages compared to roentgen control].

[Article in German]
Baar H, Danhauser I, Rothhammer A.


[The placement of a PVC catheter under intracavitary ECG control].

[Article in Spanish]
Garcia Lizarralde J.
Multiorificed catheter placement with an intravascular electrocardiographic technique.

Johans TG.

PMID: 3954145


[The intracavitary electrocardiogram for checking catheters in the right atrium].

[Article in Spanish]
Alvarez J, Cabrera JC, Bigorra S, Zueras R, Villar Landeira JM.


[Clinical use of a new cava catheter with an ECG lead over a steel mandrin].

[Article in German]
Hausser J₁.
[Positioning of central venous catheters using ECG].

Kjelstrup T, Ludwig M, Hüsch M.


Avoiding complications and decreasing costs of central venous catheter placement utilizing electrocardiographic guidance.

Francis KR, Picard DL, Fajardo MA, Pizzi WF.


[Intracavitary electrocardiography. A useful method for checking the correct localization of central venous catheters].

Garutti I, Olmedilla L, Pérez-Peña JM, Jiménez C, Sanz J, Navia J.
Central venous catheter placement using the ECG-guided Cavafix-Certodyh SD catheter.
Corsten SA, van Dijk B, Bakker NC, de Lange JJ, Scheffer GJ.

[Central venous catheter location by endocavitary ECG: an alternative to chest radiography].
[Article in Spanish]
Calabuig R, Suarez A, Galera MJ, Ortiz C, Pi F, Sierra E.

Failure to attain electrocardiogram-facilitated positioning of right atrial catheters when using the Arrow Antecubital Central Venous Catheterization Kit.
Lanier WL.

[Method for determining the position of the catheter end in the central vein].
[Article in Russian]
Tsygankov VN, Kontakevich MM, Zuevskaya EB.


[Accurate placement of central venous catheter--ECG-guided method vs patient height method].
[Article in Japanese]
1981 – 2003: prehistory

First scientific papers about IC-ECG as tip location (most of them from Europe)

The method is regarded as easy and inexpensive

The ‘accuracy’ is tested (inevitably) comparing with chest x-ray

Clinical use is limited to some European hospitals (particularly in Germany, Belgium, Austria, and Italy); in my hospital, IC-ECG use started in 1997.
2004-2019: The golden age
A few German studies discuss about the difference between the ‘saline column technique’ and the ‘wire technique’ (Pawik) and about the possibility of false positives (Schummer).


Central venous catheter placement: comparison of the intravascular guidewire and the fluid column electrocardiograms.

Pawlik MT, Kutz N, Keyl C, Lemberger P, Hansen E.
**Eur J Anaesthesiol. 2004 Aug;21(8):600-5.**

**ECG-guided central venous catheter positioning: does it detect the pericardial reflection rather than the right atrium?**

Schummer W¹, Schummer C, Müller A, Steenbeck J, Fuchs J, Bredie D, Hüttemann E.


**Central venous catheters—the inability of 'intra-atrial ECG' to prove adequate positioning.**

Schummer W¹, Schummer C, Schelenz C, Brandes H, Stock U, Müller T, Leder U, Hüttemann E.

**Anaessthesiol Intensivmed Notfallmed Schmerzther. 2005 Feb;40(2):91-6.**

**[Extravasal position of central venous catheters despite unsuspicous ECG-guidance].**

[Article in German]

Schummer W¹, Schummer C, Paxian M, Stock U, Richter K, Bauer M.
Three very important clinical studies finally validate the IC-ECG method using the Trans-Esophageal Echocardiography, showing that IC-ECG is more accurate than chest x-ray:

- Chu 2004
- Jeon 2006
- Ender 2009
Accurate Central Venous Port-A Catheter Placement: Intravenous Electrocardiography and Surface Landmark Techniques Compared by Using Transesophageal Echocardiography

Koung-Shing Chu, MD*, Jong-Hau Hsu, MD†, Shie-Shan Wang, MD‡, Chao-Shun Tang, PhD§, Kuang-I Cheng, MD$, Chien-Kuo Wang, MD¶, and Jiunn-Ren Wu, MD†

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Transesophageal echocardiographic evaluation of ECG-guided central venous catheter placement

[Évaluation échocardiographique transosophagienne de la mise en place d'un cathéter veineux central guidée par ECG]

Yunseok Jeon MD,* Ho-Geol Ryu MD,* Seung-Zhoo Yoon MD,* Jin-Hee Kim MD,† Jae-Hyon Bahk MD‡


Transesophageal echocardiography for verification of the position of the electrocardiographically-placed central venous catheter.

Ender J¹, Erdoes G, Krohmer E, Othloff D, Mukherjee C.
The first randomized controlled study is published (Gebhard 2007)

The first studies applying IC-ECG to peripherally inserted central catheters (PICC) are published (Pittiruti 2008 and Moureau 2010)
The Accuracy of Electrocardiogram-Controlled Central Line Placement

Ralf E. Gebhard, MD*
Peter Szmuk, MD†
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Vladimir Melnikov, MD‡
Christanne Vogt, MD‡
Robert D. Warters, MD‡

BACKGROUND: Electrocardiogram (ECG) guidance to confirm accurate positioning of central venous catheters (CVC), placed before surgery in the operating room, is rarely used in the United States. We designed this randomized, controlled trial to investigate whether the use of this technique impacts the accuracy of CVC placement.

METHODS: Patients in group ECG (n = 147) had a CVC placed using right-atrial ECG to guide catheter tip positioning. CVCs in group NO-ECG (n = 143) were positioned without this technique.

RESULTS: Overall, guidewire-ECG control resulted in more correctly positioned CVCs (96% vs 76%, P = 0.001) without increasing placement time. Significantly more CVCs were placed in the middle of the superior vena cava in group ECG (P = 0.001), although placement into the right atrium or right ventricle and into other vessels occurred significantly more often in group NO-ECG (P ≤ 0.001). Twenty patients in group NO-ECG required repositioning of their CVC after surgery, whereas this maneuver was necessary only in three patients in group ECG (P ≤ 0.001).

CONCLUSIONS: ECG guidance allows for more accurate CVC placement, and should be considered to increase patient safety and reduce costs associated with repositioning procedures.

(Anesth Analg 2007;104:65-70)
first studies applying IC-ECG to peripherally inserted central catheters (PICC)

The EKG Method for Positioning the Tip of PICCs: Results from Two Preliminary Studies

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Electrocardiogram (EKG) Guided Peripherally Inserted Central Catheter Placement and Tip Position: Results of a Trial to Replace Radiological Confirmation

Nancy L. Moureau, RN, BSN, CRNI, CPUI, Glenda L. Dennis, RN, CCRN, Elizabeth Ames, RN, CCRN, Robyn Severe, RN, BSN
First international guidelines to recommend IC-ECG:
Guidelines of the European Society of Parenteral and Enteral Nutrition

ESPEN Guidelines on Parenteral Nutrition: Central Venous Catheters
(access, care, diagnosis and therapy of complications)

Mauro Pittiruti a, Helen Hamilton b, Roberto Biffl c, John MacFie d, Marek Pertkiewicz e

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b John Radcliffe Hospital, Oxford, United Kingdom
c Division of Akdeniz Pelvic Surgery, European Institute of Oncology, Milano, Italy
d Scarborough Hospital, Scarborough, United Kingdom
e Medical University of Vienna, Poland

«Ideally, the position of the tip should be checked during the procedure, either by fluoroscopy or by the ECG method»
Many clinical studies are published, mostly from Europe (Italy, Germany, Spain, The Netherlands), discussing the IC-ECG for several different central venous access devices, including PICCs.

From 2009 on, the first ECG monitors specifically dedicated to IC-ECG appear on the market.
The electrocardiographic method for positioning the tip of central venous catheters

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Optimized method for correct left-sided central venous catheter placement under electrocardiographic guidance

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Endovascular electrocardiography to guide placement of totally implantable central venous catheters in oncologic patients

Cecilia Pelagatti, Gianluca Villa, Andrea Casini, Cosimo Chelazzi, Angelo Raffaele De Gaudio

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Intra-cavitary ECG is an effective method for correct positioning of the tip of tunneled Groshong catheters

Giuseppe Capozzoli, Gino Accinelli, Loris Fabbro, Roberta Pedrazzoli, Franco Auricchio
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The intracavitary ECG method for positioning the tip of central venous catheters: results of an Italian multicenter study

Mauro Pittiruti¹, Daniele Bertollo², Ermanno Briglia³, Massimo Buonomato⁴, Giuseppe Capozzoli⁵, Luigi De Simone⁶, Antonio La Greca⁷, Cecilia Pelagatti⁸, Pier Sandro Sette⁹

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The first multicenter study about IC-ECG
[Intracavitary electrocardiogram during the insertion of peripherally inserted central catheters].

[Article in Spanish]
Ortiz-Miluy G, Sánchez-Guerra C.

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Effectiveness of electrocardiographic guidance in CVAD tip placement.

Walker G, Chan RJ, Alexandrou E, Webster J, Rickard C.

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3 Nursing Director for Research, Royal Brisbane and Women’s Hospital, Australia.

Evaluation of the correct position of peripherally inserted central catheters: anatomical landmark vs. electrocardiographic technique

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2 Department of Oncology, Central Hospital of Bolzano, Bolzano - Italy
Electrocardiogram-Guided Peripherally Inserted Central Catheter Tip Confirmation Using a Standard Electrocardiogram Machine and a Wide-Mouth Electrocardiogram Clip Compared with Traditional Chest Radiograph

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Jennifer Rheingans, PhD, RN-BC, AHN-BC
Janet Steves, MBA, BSN, RN, CPAN, CENP
Mary Moretti, BS, BA, RN, PICC Team
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Successful Implementation of Electrocardiogram-Placed Peripherally Inserted Central Catheters at a Major Academic Medical Teaching Organization

Lorelle Wuerz, MSN, BS, BA, RN, VA-BC
Joseph Cooke, MD
Keith Hentel, MD, MS
Joan Ince-Barnes, BSN, RN, VA-BC
New York Presbyterian Hospital, New York, NY
Robert Dawson, DNP, MSA, APRN, ACNP-BC, VA-BC
Vascular Access Consultants LLC, Nashua, NH, and Concord Hospital, Concord, NH
Electrocardiographic-guided tip positioning technique for peripherally inserted central catheters in a Dutch teaching hospital: Feasibility and cost-effectiveness analysis in a prospective cohort study

Arthur Bloemen, Anne M Daniels, Martine G Samyn, Roel JL Janssen and Jan-Willem Elshof
In the decade 2008 – 2018, many issues become clear:

- The maximal height of the P wave represents faithfully the CAJ (i.e., the crista terminalis)
- The maximal height of the P wave is NOT related to the sino-atrial node, but to the transition between electrically inactive tissue (SVC) and electrically active tissue (atrium)
- The best way to detect the maximal P wave - avoiding false positives - is to look at the ‘pattern’ of changes (increasing P - peak – decreasing or diphasic P)
China steps in!

The IC-ECG becomes popular in China, particularly for PICCs, as documented by many clinical studies published in recent years.
Factors Influencing Intracavitary Electrocardiographic P-Wave Changes during Central Venous Catheter Placement

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RESEARCH ARTICLE

Superior success rate of intracavitary electrocardiogram guidance for peripherally inserted central catheter placement in patients with cancer: A randomized open-label controlled multicenter study

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Clinical application of electrocardiogram-guided tip positioning in peripheral inserted central catheters placement.

Yu-Xia Yin1,2, Wei Gao3, Xu-Ying Li4, Wei Lu5, Qian-Hong Deng6, Cui-Yun Zhao7, Xue-Rong Liu8, Chao Zhou1,2, Wen-Bo Hou2, Shou-Tao Lu2, Guang Liu2, Lu-Ning Wang1, Mao-Quan Li9 and Hai-Jun Zhang2,9

Abstract

Introduction: Ultrasound-guided venipuncture and tip location by intracavitary electrocardiogram have many advantages during the insertion of peripherally inserted central catheters, both in terms of safety and cost-effectiveness. Recently, a new tip-conductive peripherally inserted central catheters and new Doppler ultrasound device integrated with intracavitary electrocardiogram have been introduced into clinical practice in China. A randomized multicenter study (clinical trial no. NCT03230357) was performed to verify the feasibility and accuracy of intracavitary electrocardiogram, as performed with this new peripherally inserted central catheters and device.

Methods: Our study enrolled a total of 2250 adult patients in 10 different Chinese hospitals. The patients were randomly assigned to either the study group (intracavitary electrocardiogram) or the control group (anatomical landmark guidance) in a 2:1 allocation. Ultrasound was used in both groups for venipuncture and tip navigation. All patients underwent chest X-ray after the procedure to verify the position of the catheter tip.

Results: No insertion-related complications were reported in either group. In the study group, first-attempt successful tip location was 91.7% (95% confidence interval: 90.3%–93.1%), significantly higher than 78.9% (95% confidence interval: 76.0%–81.9%) observed in the control group (p < 0.001). As evaluated by post-procedural chest X-ray, tip location in the study group had a sensitivity of 99.3% (95% confidence interval: 98.8%–99.7%), significantly higher than 86.8% (95% confidence interval: 84.4%–89.2%) observed in the anatomical landmark group (p < 0.001).

Conclusion: These results indicated that during peripherally inserted central catheters insertion in adult patients, tip location with intracavitary electrocardiogram guidance, as carried out by a new tip-conductive peripherally inserted central catheters and intracavitary electrocardiogram integrated ultrasound device, was more effective and more accurate than tip location using anatomical landmarks.

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Meta-analysis of intracavitary electrocardiogram guidance for peripherally inserted central catheter placement

Guang Liu1, Wenbo Hou1, Chao Zhou1, Yuxia Yin1, Shoutao Lu1, Cuihai Duan1, Maoquan Li1, Egon Steen Toft3 and Haijun Zhang1,2,4

The diagnostic value of intracavitary electrocardiogram for verifying tip position of peripherally inserted central catheters in cancer patients: A retrospective multicenter study

Ting Yu1, Ligui Wu1, Ling Yuan1, Robert Dawson1, Rongmei Li1, Zhenzhu Qiu3, Xiancui Wu4, Ping Chen5, Jing Qi6, Yiqun Yang7, Yuling Feng8, Wei Xu9, Weiwei Kong1, Yang Chen1, Shanping Li1, Xiang Wu9 and Tingting Yan1

Guide wire electrode versus liquid electrode for intravascular electrocardiography–guided central venous catheterization in adults: A systematic review and meta-analysis

Guo Ling1, Wang Zhiwen2,3, Wang Guorong1, Shang Shaomei2,3 and Wu Xue2,3
IC-ECG in pediatrics
The first experiences with IC-ECG in pediatric patients are very old (more than 25 years ago)

IC-ECG is tested in neonates and children in many studies, mostly from Europe (Italy, Germany, France, Spain) but also from USA and – more recently – from China.

IC-ECG is used for any central device: ECC, UVC and CICC (neonates); CICC and PICC (children)
[Electrometric control of the position of a venous catheter in children].
[Article in Russian]
Stabletskii AD, Marochkov AV.

Location of central venous catheters in children by endocavitary ECG: A new technique.
Serafini G¹, Pietrobono P, Cornara G.

[Positioning of a central venous catheter in children by intracavitary ECG. A new technic].
[Article in Italian]
Serafini G, Pietrobono P, Perigi GB, Cornara G.
Central Venous Catheters—No X-Rays Needed: A Prospective Study in 50 Consecutive Infants and Children


Toronto, Ontario

Die zentralvenöse Plazierung des Silastikkatheters durch Ableitung eines intravasalen EKG

Eine prospektive Untersuchung an 50 Frühgeborenen unter 1000 g

A.-P. Neubauer
Aus dem Kinderkrankenhaus auf der Bult Hannover (Direktor d. Neonatol. Abt.: Prof. Dr. Natzschka)


Placement of central venous catheters by cut-down with electrocardiogram positioning.

Redo SE1, Dinner MH.

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Zachariou Z, Daum R.


Percutaneous central iv access in the neonate: experience with 535 silastic catheters

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Accurate placement of central venous catheters in pediatric patients using endocavitary electrocardiography: reassessment of a personal technique.

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Central venous catheter placement in children: evaluation of electrocardiography using J-wire

L. Simon, A. Teboul, N. Gwinner, G. Boulay, S. Cerceau-Delaporte and J. Hamza
Service d'anesthésie pédriatrique, Hôpital St Vincent de Paul, 75014 Paris, France

Cost comparison of electrocardiography versus fluoroscopy for central venous line positioning in children.

Tierney SN, Kelke J, Langer JC.

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[Positioning of umbilical vein catheter with ECG-guided technique: randomized study].

[Article in Italian]
Biban P, Cavalli C, Santuz P, Soffiati M, Rugolotto S, Zanardi T.

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Determination of the optimal length of insertion of central venous catheters in pediatric patients by endovascular ECG.

Weber F, Buitenhuys M, Lequin MH.

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The intracavitary ECG method for positioning the tip of central venous access devices in pediatric patients: results of an Italian multicenter study

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The first multicenter study about IC-ECG in children
First pediatric guidelines to recommend IC-ECG: Guidelines of the Italian Society of Pediatric Oncology (AIEOP)

«The tip location should be ideally verified in real time during the procedure (by fluoroscopy, by intracavitary electrocardiography or by echocardiography) or — as a second option — soon after the procedure (by chest x-ray or by echocardiography)».
Lian-juan Zhou, Hong-zhen Xu*, Mei-fang Xu, Yan Hu, Xiao-Fang Lou

An accuracy study of the Intracavitary Electrocardiogram (IC-ECG) guided peripherally inserted central catheter tip placement among neonates


Effectiveness of Intracavitary Electrocardiogram Guidance in Peripherally Inserted Central Catheter Tip Placement in Neonates.

Zhou L1, Xu H, Liang J, Xu M, Yu J.

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1 Departments of Nursing (Mss Zhou, Xu, and Yu); and Medical Statistics (Mr Liang), Children's Hospital, Zhejiang University School of Medicine, Hangzhou, PR China.
The intracavitary electrocardiography method for positioning the tip of epicutaneous cava catheter in neonates: Pilot study

Antonella Capasso1, Rossella Mastroianni1, Annalisa Passariello2,3, Marta Palma2, Francesco Messina4, Antonella Ansalone1, Italo Bernardo1, Daniela Brescia1, Francesco Crispino1, Carolina Grassia1, Attilio Romano1 and Gaetano Ausanio1

The intracavitary electrocardiography method for tip location of jugular internal vein access device in infants of less than 5 kg: A pilot study

Rossella Mastroianni, Antonella Capasso and Gaetano Ausanio

Evaluation of a Magnetic Tracking and Electrocardiogram-based Tip Confirmation System for Peripherally Inserted Central Catheters in Pediatric Patients.

Rosche N1, Stehr W.
Repositioning of malpositioned peripherally inserted central catheter lines with the use of intracavitary electrocardiogram: A pediatric case series

Mark D Weber, Adam S Himebauch and Thomas Conlon

Accuracy and Safety Study of Intracavitary Electrocardiographic Guidance for Peripherally Inserted Central Catheter Placement in Neonates.

Ling Q, Chen H, Tang M, Qu Y, Tang B.

Author information

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IC-ECG can be applied in Umbilical Venous Catheters (UVC) and in Epicutaneo-Caval Catheters (ECC), though there might be some issues related to the small caliber of ECC (< 3Fr).

As ultrasound-based tip location by TTE is particularly easy and accurate in neonates, it is becoming more popular than IC-ECG for ECC and UVC.

For CICCs = or > 3Fr in neonates and for all central lines in children, on the other hand, IC-ECG is the ideal tip location method.
IC-ECG in nephrology
Haemodialysis treatment in patients with acute renal failure and other severe clinical conditions requires prompt placement of a safe and quick vascular access which, in many cases, is required to last for a long period.

During the last decade, cannulation of the femoral vein, subclavian vein and more recently, the internal jugular vein (IJV) has been performed to obtain central vascular access.

Femoral catheterization is associated with a high prevalence of infective complications and phlebothrombosis of the femoral iliac axis even after only a few days of placement. It is well known that the major complication of subclavian dialysis catheter use is vessel stenosis, particularly when the catheter is used for a long period. A study by Cimochowsky et al. has clearly defined the prevalence of this complication: 50-58% of patients with a subclavian catheter show significant stenosis. On occasion, angiography studies have revealed total lumen occlusion after only a few days following catheter placement, and furthermore, with haemodynamic consequences that involve the whole homolateral limb, particularly when a new surgical vascular access is performed.

According to the most recent literature, IJV catheterization represents the best choice for central venous access. Since correct positioning of the catheter is the most important requirement for its immediate use, we propose the placement of the central vein catheter by percutaneous puncture of IJV and the immediate control of the position of the catheter.
The placement of central venous catheters in hemodialysis: role of the endocavitary electrocardiographic trace. Case reports and literature review

P. DIONISIO†, F. CAVATORTA†, A. ZOLLO†, M. VALENTI†, N. CHIAPPINI†, P. BAJARD†
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Real-time ultrasound and endocavitary electrocardiography for venous catheter placement

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Central venous catheter placement in hemodialysis: evaluation of electrocardiography using a guide-wire

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Evaluating central venous catheters by endocavitary ECG.

[Article in Italian]

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Application of intravenous electrocardiography for insertion of central veins dialysis catheters.

Beigi AA¹, Parvizian F, Masoudpour H.
The intracavitary ECG method for insertion of a tunneled dialysis catheter without using fluoroscopy

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Most studies about IC-ECG in dialysis catheters are from Italy, where this tip location method is quite popular.

The IC-ECG is easy, inexpensive and accurate also for dialysis catheters.

The advantage of IC-ECG for dialysis is the possibility of comparison the ECG tracing between the two lumens.

The value of IC-ECG may be limited when a lumen has different holes, at different distance from the tip.
The state of the art in 2020
Tip location is mandatory in all central VAD insertions

Any central venous access device (PICC, CICC, chest-port, PICC-port, dialysis cath., etc.) inserted through of a vein of the upper arm or a vein of the cervico-thoracic area should have its tip properly placed in the lower part of the superior vena cava or in the upper part of the right atrium (depending on the performance required).

Any central venous access device (FICC, groin-port, dialysis cath., etc.) inserted through of a vein of the inguinal area should have its tip properly placed in the middle part of the inferior vena cava or in the right atrium (depending on the performance required).
‘tip location’ methods

**DURING THE PROCEDURE**
- Intracavitary ECG
- Fluoroscopy
- Echocardiography (TTE, TEE)

**AFTER PROCEDURE**
- Chest x-ray
- CT, MR, angiography
- Echocardiography (TTE)
Post-procedural control of tip location is associated with the possible need for repositioning the tip. Which implies:

• waste of time
• waste of resources
• potential harm to the patient

Use methods for identifying CVAD tip location during the insertion procedure (i.e., “real time”) due to greater accuracy, more rapid initiation of infusion therapy, and reduced costs.
5. Postprocedure radiograph imaging is not necessary if alternative tip location technology confirms proper tip placement.\textsuperscript{3,12-18} (II)
Confirmation of tip location by postprocedure chest radiograph remains acceptable practice and is required in the absence of technology used during the procedure. \textbf{This method is less accurate} because the CAJ cannot be seen on the radiograph, requiring identification of tip location by measurement from the carina, trachea-bronchial angle, or thoracic vertebral bodies. Additionally, a change in the patient position from supine to standing, usually required for the radiograph, results in movement of the catheter tip by as much as 2 cm.\textsuperscript{3,11,12,19,20} (II)
There are three main intra-procedural methods for tip location

- Intracavitary ECG (IC-ECG)
- Fluoroscopy
- Echocardiography
Intracavitary ECG (IC-ECG) is the preferred method for intra-procedural tip location

- Accurate
  - More accurate than radiology
  - Less accurate than trans-esophageal echocardiography (TEE)
- Inexpensive
- 100% Safe
- Easy to perform
- Easy to learn
- Applicable to any type of CVAD
Tip location should preferably performed by IC-ECG

Use methods for identifying CVAD tip location during the insertion procedure (ie, “real time”) due to greater accuracy, more rapid initiation of infusion therapy, and reduced costs.

1. Use electrocardiogram (ECG) methods with either a metal guidewire or a column of normal saline inside the catheter lumen and observe the ECG tracing to place the CVAD tip at the CAJ.
Conventional IC-ECG has some limitations of applicability

- ‘Conventional IC-ECG’ is based on the interpretation of changes of P-wave
  - Maximal P wave = CAJ
  - In particular: identification of a specific pattern (‘increasing P – maximal P – diphasic P’)

- Conventional IC-ECG cannot be carried out in conditions in which the P wave is difficult or impossible to identify
  - Atrial fibrillation
  - Pacemaker
  - Other abnormalities of cardiac rhythm with absence or hiding of P wave
In atrial fibrillation patients (7-11%), **modified IC-ECG** may replace **conventional IC-ECG** as tip location method.

A modified intracavitary electrocardiographic method for detecting the location of the tip of central venous catheters in atrial fibrillation patients

Maria Calabrese¹, Luca Montini², Gabriella Arlotta¹, Antonio La Greca³, Daniele G Biasucci², Francesca Bevilacqua¹, Enrica Antonucci¹, Andrea Scapigliati¹, Franco Cavaliere¹ and Mauro Pittiruti³
Not only AF...

...Conventional IC-ECG may be difficult also in other conditions (1-2%):

- pacemaker (if active at every beat)
- some rare cardiac arrhythmias
- some cardiovascular abnormalities (persistent left SVC)
- when the electric signal is poorly conducted
  - very small bore catheters (< 3Fr) in neonates
- .....................
Tip location by fluoroscopy

• Acceptable as accuracy
  • Though, less accurate than echocardiography or IC-ECG

• Expensive

• Unsafe
  • X-ray exposure

• Logistically difficult
  • Particularly for bedside CVADs (PICC and CICC)
Tip location by fluoroscopy: only in exceptional cases
Avoid fluoroscopy except in the case of difficult CVAD insertions, as it requires exposure to ionizing radiation.
Tip location by echocardiography (TEE)

**TEE : Trans-esophageal echocardiography**

- The **most accurate method** for tip location
- Invasive
  - Esophageal probe
- Expensive
- Logistically impossible in the vast majority of patients
  - Feasible for CICCs before/during cardiac surgery
  - Not feasible for routine bedside placement
Tip location by echocardiography (TTE)

TTE: trans-thoracic echocardiography
• Accuracy depending on the method used and on the operator
• Widely used in Europe more than in USA
• Ideal in neonates and children
• May be difficult in some adult patients
TTE for tip location
(with or without the ‘bubble test’)
has been widely studied in the literature since 2001
Evidence of maximal safety, accuracy and cost-effectiveness
In conclusion, tip location by TTE:

Recommended for all central VADs in neonates
- particularly easy, accurate and always feasible

Not appropriate for routine use in adults and children, at the moment, but it may be useful when conventional IC-ECG or modified IC-ECG are not applicable or not feasible
- not standardized yet
- not always feasible
- requires training
Our current algorithm in neonates and children

- PICC, CICC, FICC
  - Conventional IC-ECG
  - TTE
  - No chest x-ray

- Umbilical Venous Cath
  - TTE
  - TTE

- Epicutaneo-caval Cath
  - TTE
Our current algorithm in Adults

- P wave is evident:
  - Conventional IC-ECG: No chest x-ray

- P wave is not evident:
  - Basal ECG
    - AF
    - Modified IC-ECG
      - Post-op chest x-ray only in selected cases
      - TTE
        - Non-AF
2020: the COVID pandemic
COVID = Revision of many decision-making processes and reformulation of protocols and procedures.

Our goals:

• Protect the operator
• Maximize the effectiveness of the maneuver
• Reduce the risk of complications for the patient
• Avoid a waste of resources

«Smart decisions for maximal safety»
Vascular access in COVID-19 patients: Smart decisions for maximal safety

Giancarlo Scoppettuolo¹, Daniele Guerino Biasucci² and Mauro Pittiruti³
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Recommendations for the use of vascular access in the COVID-19 patients: an Italian perspective

Mauro Pittiruti¹, Fulvio Pinelli² on behalf of the GAVeCeLT Working Group for Vascular Access in COVID-19
Strong recommendation for any CVAD inserted in COVID patients: choose wisely the insertion technique

• Please avoid radiology – ALWAYS
  (Fluoroscopy and chest-x-ray = waste of time and resources, risk of contamination, less safety, less accuracy)
  • use ULTRASOUND
    • for ultrasound-guided venipuncture
    • for tip navigation (linear probe)
    • for tip location (trans-thoracic echocardiography with convex or sector probe)
    • for ruling out pleura-pulmonary damage (linear probe)
  • use INTRACAVITARY ECG for tip location

FORGET X-RAYS!
The positive side effect of the COVID experience can take the form of a new awareness of the need to save resources and increase safety even outside of health emergency situations, adopting a few winning strategies:

- to consider the full range of peripheral and central VADs, adopting the device most appropriate for each clinical situation;
- to abandon the routine use of radiology for checking the tip location and ruling out pneumothorax after central venous access insertion, in favor of faster, more accurate, safer and cheaper methods such as intracavitary electrocardiography and echocardiography;
- to adopt strategies that maximize the securement and the protection of the exit site of central venous catheters (subcutaneously anchored securement and cyanoacrylate glue);
- to adopt systematically appropriate techniques of infection prevention in order to maximize both patient and operator safety during insertion of vascular access devices.
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Conclusions
Take home messages

1) Use ALWAYS an intraprocedural method
   The old method (‘blind’ insertion by length estimation only + post-procedural x-ray) is simply not acceptable any more

2) Avoid fluoroscopy
   It is expensive, inaccurate and unsafe

3) Use conventional IC-ECG whenever the P is evident

4) Use modified IC-ECG and/or TTE whenever the P is not evident
   Add post-procedural x-ray control in some selected cases
Thank you for your attention

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