UNIVERSITÀ CATTOLICA del Sacro Cuore

GAVeCeLT
Gli Accessi Venosi Centrali a Lungo Termine

GloVANet
Global Vascular Access Network

# How to verify tip location of central venous access: the state of the art

**Mauro Pittiruti**

**Catholic University Hospital, Rome (Italy)**

# 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).

# Central tip locations

| | Non-peripherally compatible infusions | Blood sampling | Hemodialysis | CVP/PICCO | SvO2 |
|---|---|---|---|---|---|
| Lower 1/3 SVC | **yes** | **yes** | **no** | **yes** | **no** |
| Right atrium | **yes** | **yes** | **yes** | **yes** | **yes** |
| IVC | **yes** | **yes** | **yes** | **no** | **no** |

# Main ‘tip location’ methods:

**DURING THE PROCEDURE**

- Intracavitary ECG
- Fluoroscopy
- Echocardiography (TTE, TEE)

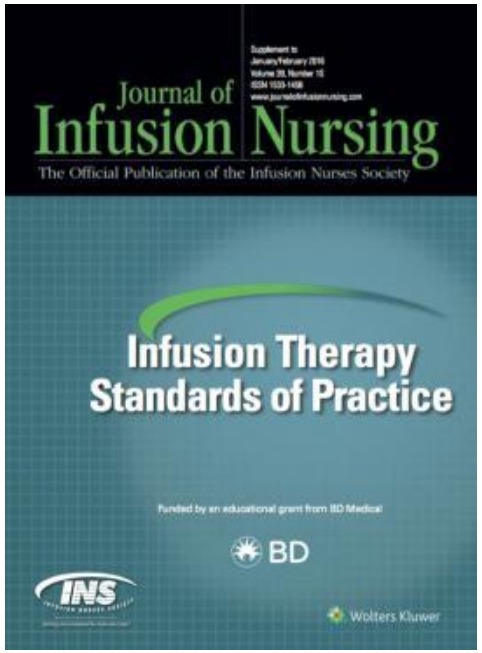
**AFTER PROCEDURE**

- Chest x-ray
- CT, MR, angiography
- Echocardiography (TTE, TEE)

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

2016



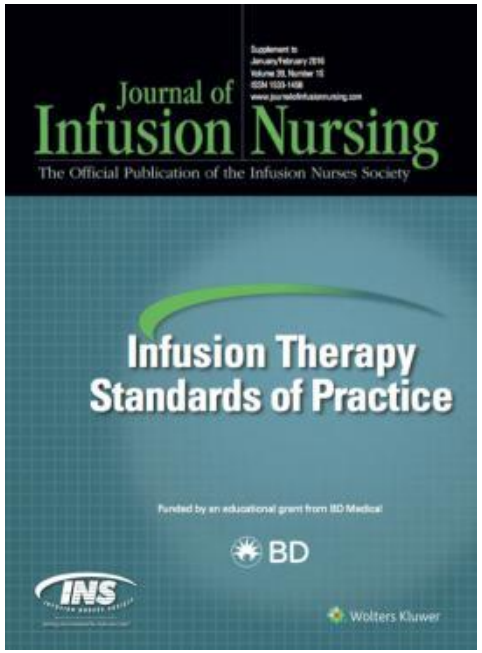

Use methods for identifying CVAD tip location during the insertion procedure (ie, "real time") due to greater accuracy, more rapid initiation of infusion therapy, and reduced costs.

# Post-procedural chest x-ray: only in exceptional cases

5. Postprocedure radiograph imaging is not necessary if alternative tip location technology confirms proper tip placement.[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. 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.[3,11,12,19,20] (II)

2016

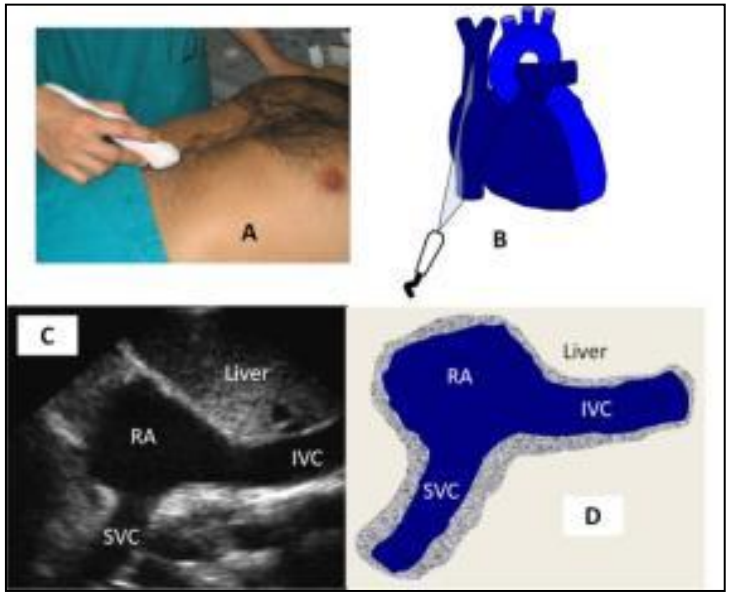


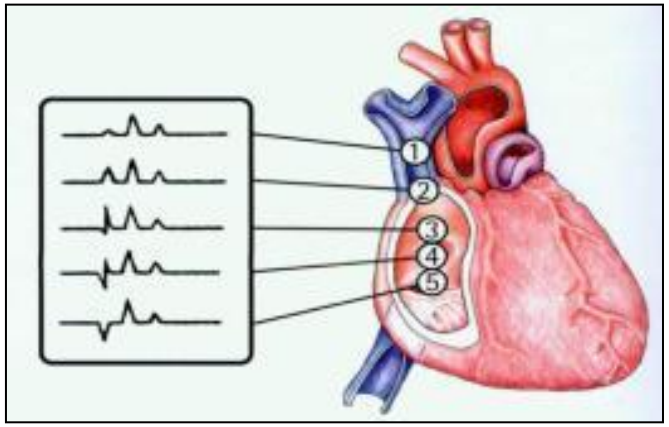
- Length estimation by surface landmark + post-procedural control of tip location is not acceptable any more

- We MUST adopt **an intraprocedural method** of tip location

# There are three main intra-procedural methods for tip location

- Fluoroscopy
- Echocardiography (TEE or TTE)
- Intracavitary electrocardiography (IC-ECG)




# 70 years of clinical studies on IC-ECG

JVA The Journal of Vascular Access

*Review*

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

**Mauro Pittiruti[1], Filippo Pelagatti[2] and Fulvio Pinelli[3]**

The Journal of Vascular Access
1–8

DOI: 10.1177/1129729820929835
journals.sagepub.com/home/jva
SAGE

Proc Soc Exp Biol Med. 1949 May;71(1):58-60.

## 17078. Recording of Intracavity Potentials Through a Single Lumen, Saline Filled Cardiac Catheter.

H. K. HELLERSTEIN,* W. H. PRITCHARD, AND R. L. LEWIS.

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

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* Fellow of the National Institute of Health.

# 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 - 2009

**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†

*Department of Anesthesiology, Kuo General Hospital, Tainan, Taiwan; and Departments of †Pediatrics, ‡Surgery, §Anesthesiology, and ‖Medical Imaging, Kaohsiung Medical University, Kaohsiung City, Taiwan

2004

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# Transesophageal echocardiographic evaluation of ECG-guided central venous catheter placement

*[Évaluation échocardiographique transœsophagienne 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‡

2006

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J Cardiothorac Vasc Anesth. 2009 Aug;23(4):457-61. doi: 10.1053/j.jvca.2008.12.003. Epub 2009 Feb 13.

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

Ender J[1], Erdoes G, Krohmer E, Olthoff D, Mukherjee C.

2009

# 2007 - 2010

**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)**

# first randomized controlled study

## The Accuracy of Electrocardiogram-Controlled Central Line Placement

Ralf E. Gebhard, MD*

Peter Szmuk, MD†

Evan G. Pivalizza, MBChB, FFASA‡

Vladimir Melnikov, MD‡

Christianne 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%, $P \leq 0.001$) without increasing placement time. Significantly more CVCs were placed in the middle of the superior vena cava in group ECG ($P \leq 0.001$), although placement into the right atrium or right ventricle and into other vessels occurred significantly more often in group NO-ECG ($P \leq 0.001$). 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 ($P \leq 0.001$).

**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)

2007

# 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

Mauro Pittiruti[1],MD, Giancarlo Scoppettuolo[2],MD, Antonio La Greca[1], MD, Alessandro Emoli[3], RN, Alberto Brutti[4], RN, Ivano Migliorini[1], RN, Laura Dolcetti[2], RN, Cristina Taraschi[2], RN, Gennaro De Pascale[2], MD
[1]Dept. of Surgery, [2]Dept. of Infectious Diseases, [3]Dept. of Oncology, [4]Intensive Care Unit
Catholic University Hospital, Rome, Italy

2008

## 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

2010

# First international guidelines to recommend IC-ECG: Guidelines of the European Society of Parenteral and Enteral Nutrition

2009

Clinical Nutrition 28 (2009) 365–377

Contents lists available at ScienceDirect

Clinical Nutrition

journal homepage: http://www.elsevier.com/locate/clnu

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

Mauro Pittiruti [a], Helen Hamilton [b], Roberto Biffi [c], John MacFie [d], Marek Pertkiewicz [e]

[a] Catholic University Hospital, Roma, Italy
[b] John Radcliffe Infirmary, Oxford, United Kingdom
[c] Division of Abdomino-Pelvic Surgery, European Institute of Oncology, Milano, Italy
[d] Scarborough Hospital, Scarborough, United Kingdom
[e] Medical University of Warsaw, Poland

**«Ideally, the position of the tip should be checked during the procedure, either by fluoroscopy or by the ECG method»**

# The intracavitary ECG method for positioning the tip of central venous catheters: results of an Italian multicenter study

**Mauro Pittiruti[1], Daniele Bertollo[2], Ermanno Briglia[3], Massimo Buononato[4], Giuseppe Capozzoli[5], Luigi De Simone[6], Antonio La Greca[1], Cecilia Pelagatti[7], Pier Sandro Sette[8]**

[1]Department of Surgery, Policlinico Universitario 'A.Gemelli', Roma - Italy
[2]Department of Anesthesia and Intensive Care, Ospedale Civile di Varese, Varese - Italy
[3]Department of Anesthesia and Intensive Care, Ospedale Castelnuovo Monti, Reggio Emilia - Italy
[4]Department of Surgery, Ospedali Riuniti di Cremona, Cremona - Italy
[5]Department of Anesthesia and Intensive Care, Ospedale Civile di Bolzano, Bolzano - Italy
[6]Department of Anesthesia and Intensive Care, Az. Osp. Universitaria di Pisa, Pisa - Italy
[7]Department of Anesthesia and Intensive Care, Ospedale Careggi, Firenze - Italy
[8]Department of Anesthesia and Intensive Care, Ospedale Fracastoro, San Bonifacio - Italy

2012

**The first multicenter study about IC-ECG**

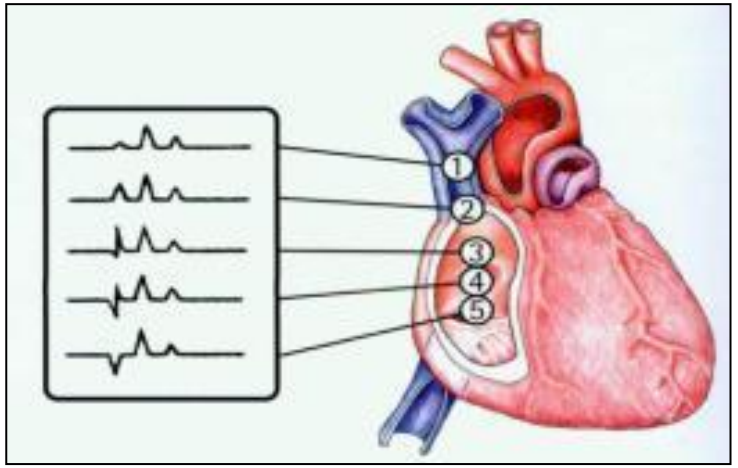
# 2008 - 2018

**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)**

# Today, 2020: Intracavitary ECG (IC-ECG) is the preferred method for intra-procedural tip location

- Accurate
  - More accurate than radiology or TTE
  - Less accurate than trans-esophageal echocardiography (TEE)
- Inexpensive
  - Less expensive than radiology or TEE
  - As inexpensive as TTE
- 100% Safe
  - Safer than radiology or TEE
  - As safe as TTE
- Easy to perform
  - Easier than radiology or TEE
  - As easy as TTE
- Easy to learn
  - Easier than radiology or TEE or TTE

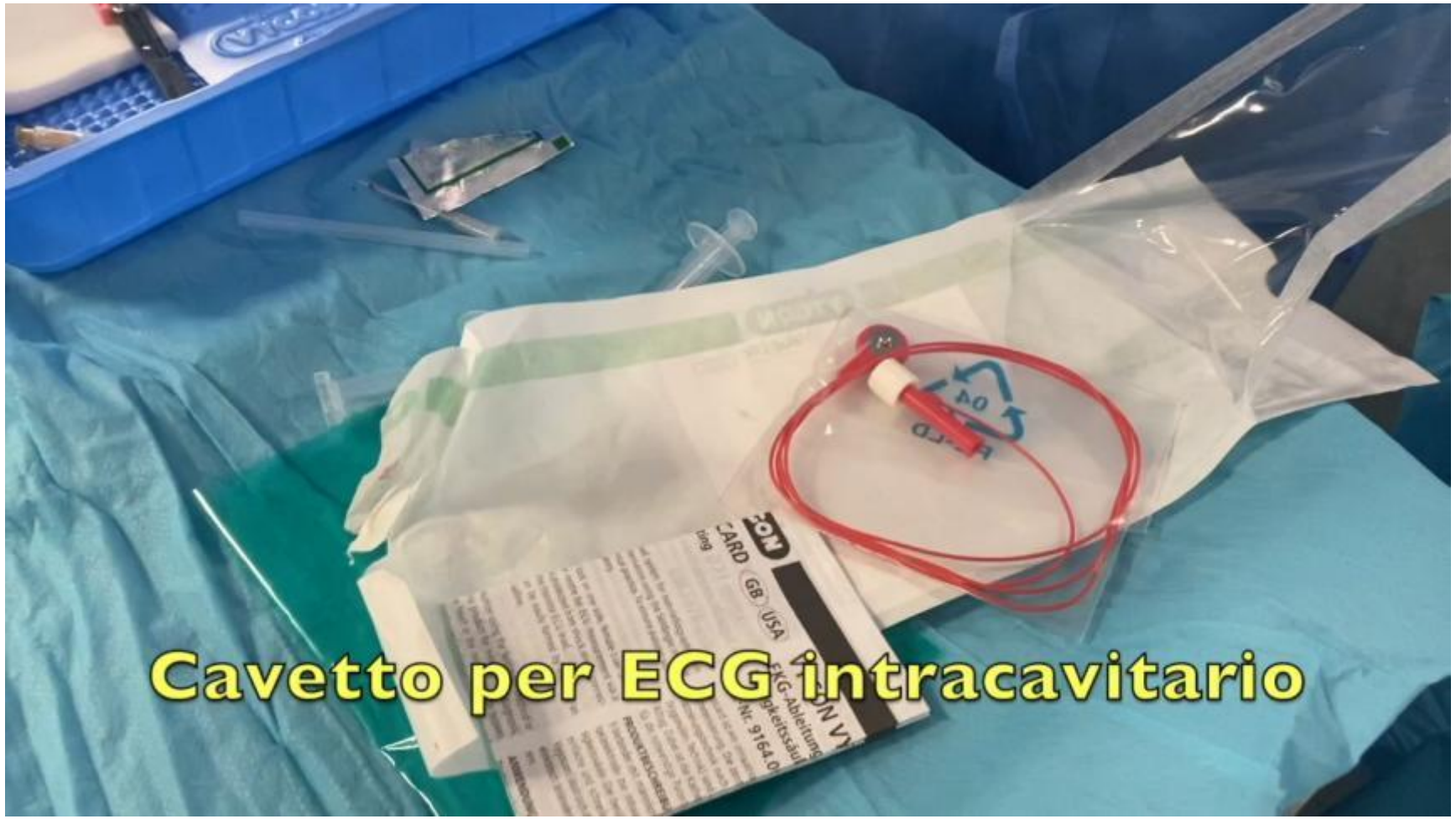



# Inexpensive !


+

**any standard ECG monitor + a sterile cable for IC-ECG**

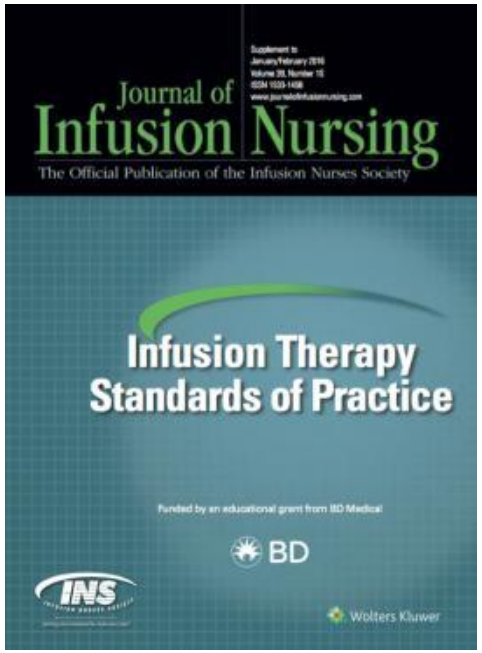
# any standard ECG monitor + a sterile cable for IC-ECG



# 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.




2016

# 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

*Original research article*

JVA | The Journal of Vascular Access

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

Maria Calabrese[1], Luca Montini[2], Gabriella Arlotta[1], Antonio La Greca[3], Daniele G Biasucci[2], Francesca Bevilacqua[1], Enrica Antoniucci[1], Andrea Scapigliati[1], Franco Cavaliere[1] and Mauro Pittiruti[3]

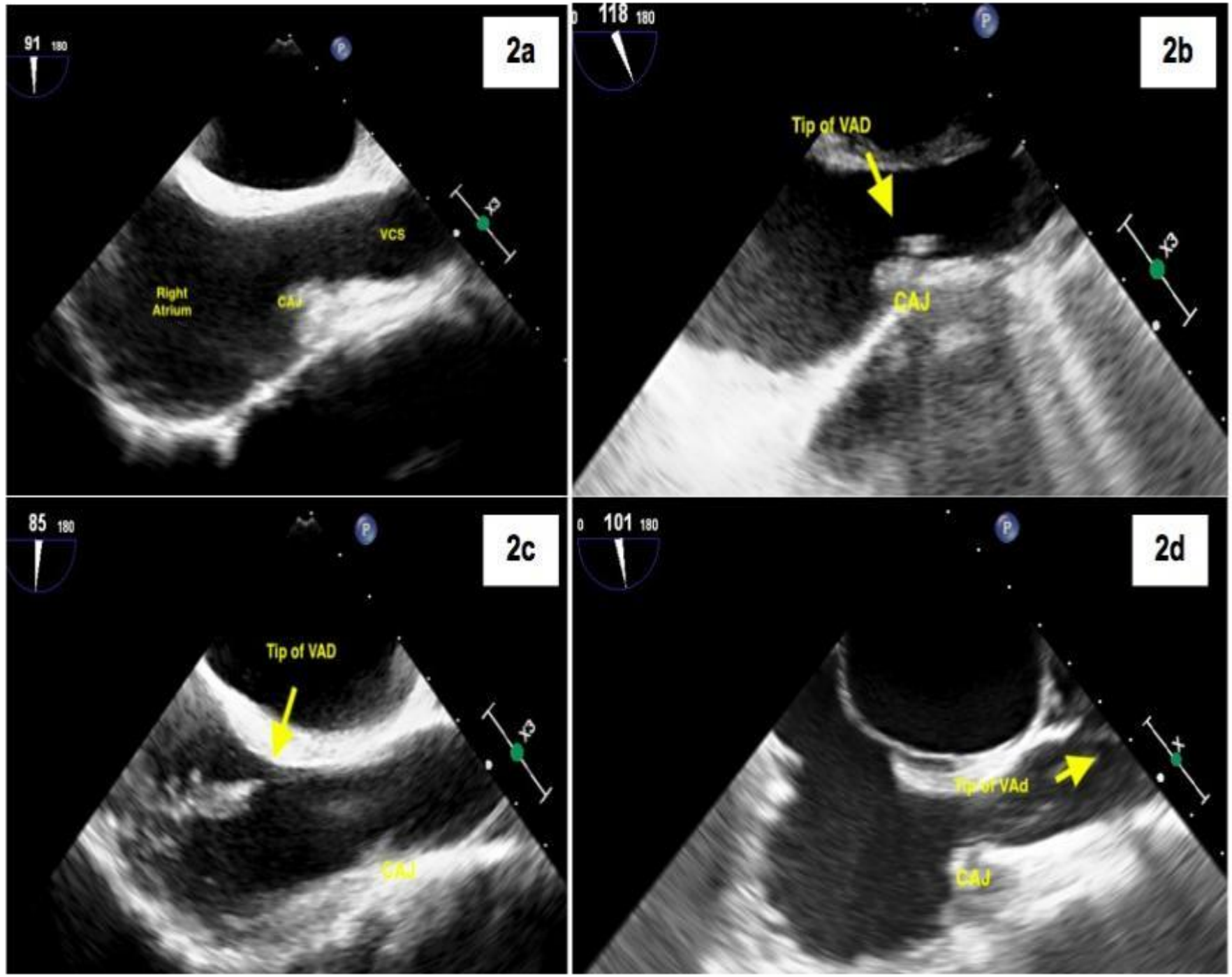
The Journal of Vascular Access
1–8

DOI: 10.1177/1129729818819422
journals.sagepub.com/home/jva
SAGE

# Methods

We studied 18 AF patients requiring simultaneously a CVC and a trans-esophageal echocardiography (TEE).

An IC-ECG trace was recorded with the catheter tip in 3 different positions defined by TEE imaging: in the **superior vena cava**, 2 cm above the cavo-atrial junction (CAJ); at the **CAJ**; and in the **right atrium**, 2 cm below the CAJ.


91 180
2a
VCS
Right Atrium
CAJ
118 180
2b
Tip of VAD
CAJ
85 180
2c
Tip of VAD
CAJ
101 180
2d
Tip of VAd
CAJ

# Methods

Three different criteria of measurement of the *f* waves pattern in the TQ tract were used:

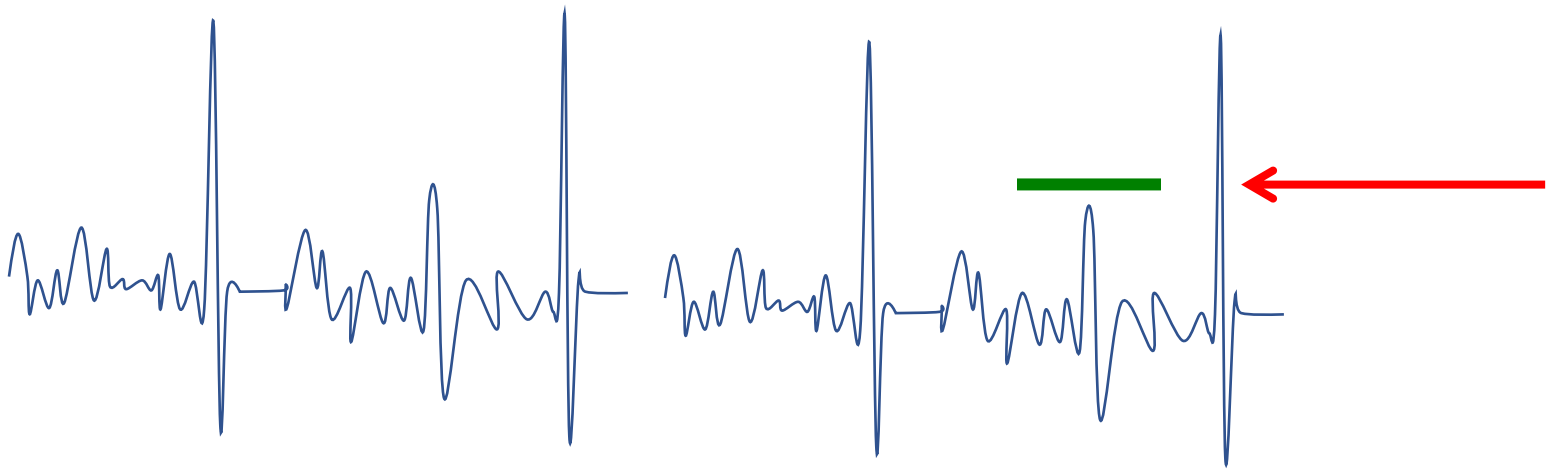
- the mean height of *f* waves **(method A)**;
- the height of the highest f wave **(method B)**;
- the difference between the highest positive peak and the lowest negative peak **(method C)**

# Method A

- Measurement of the the mean height of *f* waves

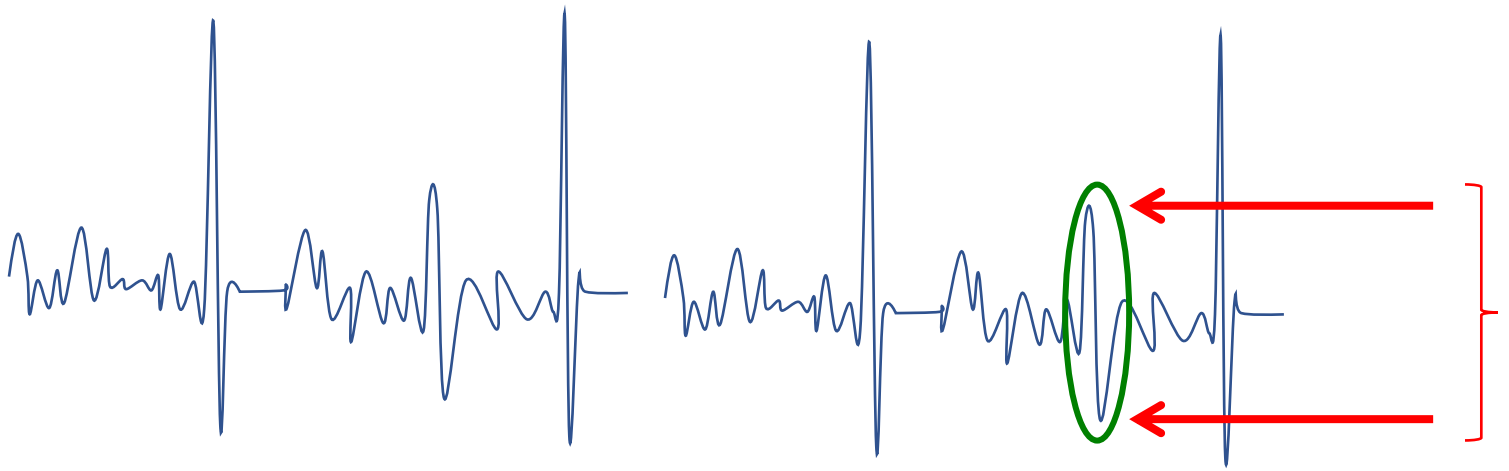
# Method B

- Measurement of the the height of the highest f wave



# Method C

- Measurement of the widest difference between maximal positive peak and maximal negative peak



With the tip placed at the CAJ, the mean value of the *f* waves was significantly higher than in the other two positions.

| Methods to measure the F-wave | Anatomical site | Mean ± SD (number of observations) | Pairwise comparison* |
|---|---|---|---|
| Method A | SVC | 1,9 ± 0,89 (385) | SVC *vs* CAJ |
| | CAJ | 3,33 ± 1,47 (590) | CAJ *vs* RA; CAJ *vs* SVC |
| | RA | 2,08 ± 0,75 (376) | RA *vs* CAJ |
| Method B | SVC | 2,11 ± 1,32 (180) | SVC *vs* CAJ |
| | CAJ | 4,52 ± 1,87 (180) | CAJ *vs* RA; CAJ *vs* SVC |
| | RA | 2,03 ± 0,9 (180) | RA *vs* CAJ |
| Method C | SVC | 2,34 ± 1,39 (180) | SVC *vs* CAJ |
| | CAJ | 5,07 ± 2,07 (180) | CAJ *vs* RA; CAJ *vs* SVC |
| | RA | 2,32 ± 0,93 (180) | RA *vs* CAJ |

**Legend**. SVC =superior vena cava; RA =right atrium; CAJ = cavo-atrial junction; SD =standard deviation; mm =millimeter.

* ANOVA was significantly different for all ($p<0.001$); each pairwise comparison was individually significant ($p<.05$) at post-hoc analysis (Scheffè test for all pairwise comparisons).

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**ANOVA**
**p <.001**
**for all**

**Pairwise**
**p <.05**
**for each**

All three methods were effective in discriminating the tip position at the CAJ, though method B proved to be the most accurate.

| Different methods to measure the *f* waves | Anatomical site | AUC ± SE (95% C.I.)* | Cut-off value (mm) ** |
|---|---|---|---|
| Method A | CAJ vs SVC | 0,71±0.016 (0,68-0,74) | > 2 |
| Method A | CAJ vs RA | 0,7±0,016 (0,67-0,73) | > 2,5 |
| Method B | CAJ vs SVC | 0,84 ±0,021 (0,79-0,87) | > 2 |
| Method B | CAJ vs RA | 0,86 ±0,018 (0,82-0,9) | > 2,5 |
| Method C | CAJ vs SVC | 0,83 ±0,02 (0,78-0,86) | > 2 |
| Method C | CAJ vs RA | 0,85 ±0,019 (0,81-0,88) | > 3 |

**Legend**. AUC =area under curve, SE =standard error, C.I. =confidence interval, mm =millimeter, SVC = Superior Vena Cava, RA = Right Atrium, CAJ = cavo-atrial junction

* A higher value of AUC with narrow 95% confidence interval means a better discrimination between two different positions.

** The cut-off value of the height of the f wave (expressed in mm) corresponds to the one associated with maximal accuracy (minimal false positive and false negative results).

| Different methods to measure the *f* waves | Anatomical site | AUC ± SE (95% C.I.)* | Cut-off value (mm) ** |
|---|---|---|---|
| Method A | CAJ *vs* SVC | 0,71±0.016 (0,68-0,74) | > 2 |
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| Method C | CAJ *vs* RA | 0,85 ±0,019 (0,81-0,88) | > 3 |

**ROC Analysis**

**Higher value of AUC = better discrimination between two different positions**

# Conclusions of our study

Our study demonstrates that a ‘modified’ IC-ECG method based not on the maximal height of the P wave but on the maximal electrical activity of the TQ tract can be safely used for detecting the location of the tip of central VADs in AF patients.

Our data also suggests that this method should replace other tip location methods currently used in AF patients, such as fluoroscopy or post-procedural chest x-ray, since such radiological techniques are less accurate, more expensive and less safe than IC-ECG.

# 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
- ……

# When conventional IC-ECG and modified IC-ECG are not applicable…

Should we use fluoroscopy ?

# When conventional IC-ECG and modified IC-ECG are not applicable…

Should we use fluoroscopy ?

NO !

# Tip location by fluoroscopy

- Acceptable as accuracy
  - Though, less accurate than echocardiography or IC-ECG
- Very expensive
  - Far more expensive than IC-ECG or TTE
- Unsafe
  - X-ray exposure ! (both for the patient and for the operator)
- Logistically difficult
  - In particular for bedside CVADs (PICC, FICC and CICC)

# Tip location by fluoroscopy: only in exceptional cases

2013

Annals of Internal Medicine | SUPPLEMENT

## The Top Patient Safety Strategies That Can Be Encouraged for Adoption Now

Paul G. Shekelle, MD, PhD; Peter J. Pronovost, MD, PhD; Robert M. Wachter, MD; Kathryn M. McDonald, MM; Karen Schoelles, MD, SM; Sydney M. Dy, MD, MSc; Kaveh Shojania, MD; James T. Reston, PhD, MPH; Alyce S. Adams, PhD; Peter B. Angood, MD; David W. Bates, MD, MSc; Leonard Bickman, PhD; Pascale Carayon, PhD; Sir Liam Donaldson, MBChB, MSc, MD; Naihua Duan, PhD; Donna O. Farley, PhD, MPH; Trisha Greenhalgh, BM BCH; John L. Haughom, MD; Eileen Lake, PhD, RN; Richard Lilford, PhD; Kathleen N. Lohr, PhD, MA, MPhil; Gregg S. Meyer, MD, MSc; Marlene R. Miller, MD, MSc; Duncan V. Neuhauser, PhD, MBA, MHA; Gery Ryan, PhD; Sanjay Saint, MD, MPH; Stephen M. Shortell, PhD, MPH, MBA; David P. Stevens, MD; and Kieran Walshe, PhD

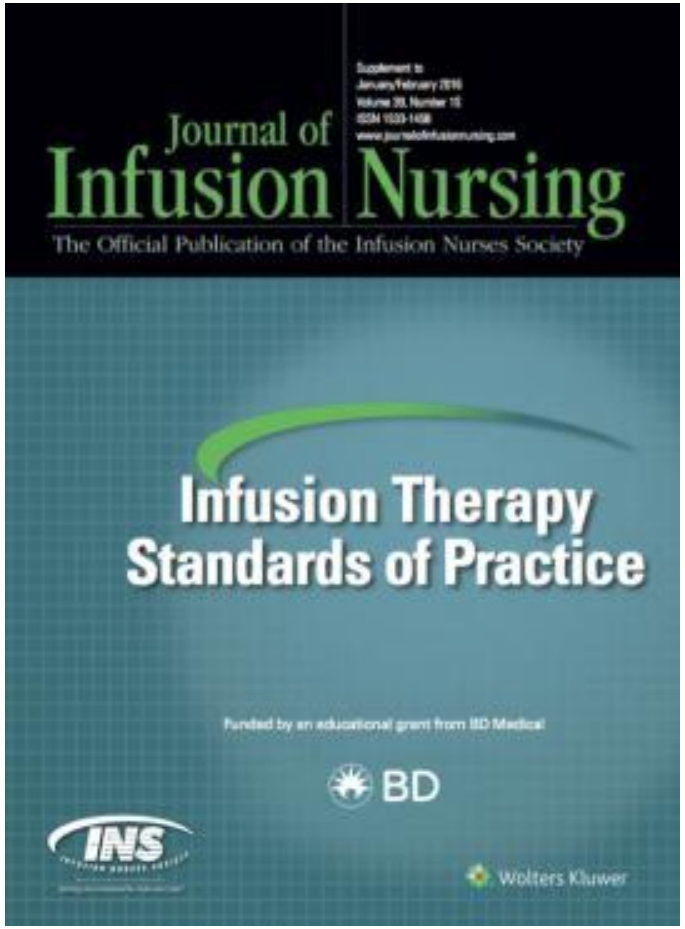
**Encouraged**

- Multicomponent interventions to reduce falls
- Use of clinical pharmacists to reduce adverse drug events
- Documentation of patient preferences for life-sustaining treatment
- Obtaining informed consent to improve patients' understanding of the potential risks of procedures
- Team training
- Medication reconciliation
- Practices to reduce radiation exposure from fluoroscopy and CT
- The use of surgical outcome measurements and report cards, such as those from ACS NSQIP
- Rapid-response systems
- Use of complementary methods for detecting adverse events or medical errors to monitor for patient safety problems
- Computerized provider order entry
- Use of simulation exercises in patient safety efforts

# Tip location by fluoroscopy: only in exceptional cases

2016

Avoid fluoroscopy except in the case of difficult CVAD insertions, as it requires exposure to ionizing radiation.



# When conventional IC-ECG and modified IC-ECG are not applicable…

Should we consider echocardiography?

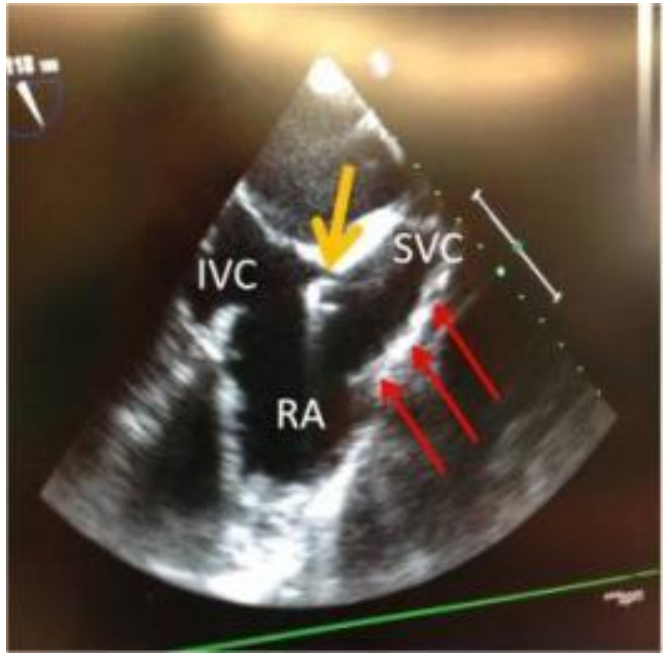
**TEE?**

**TTE?**

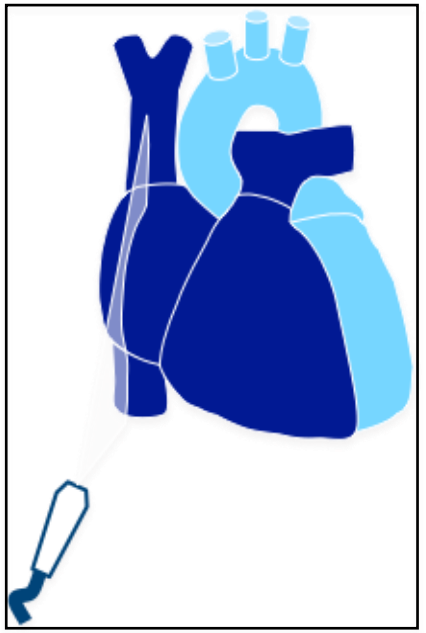
# Tip location by echocardiography (TEE)

## TEE : trans-esophageal echocardiography

- The most accurate method for tip location
- Invasive
  - Esophageal probe
- Very expensive
- Requires specific training
- Logistically impossible in the vast majority of patients
  - Feasible for CICCs before/during cardiac surgery
  - Not feasible for routine bedside placement

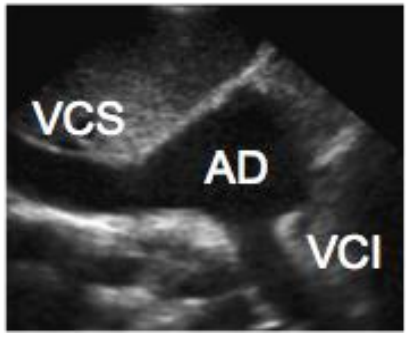


# Tip location by echocardiography (TTE)



## TTE : trans-thoracic echocardiography

- Accuracy depending on the method used and on the operator
- Easy and accurate in neonates and children
- Sometimes difficult in some adult patients
- Widely used in Europe more than in USA



Intensive Care Med
DOI 10.1007/s00134-012-2597-x

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# International evidence-based recommendations on ultrasound-guided vascular access

2012

WoCoVA-GAVeCeLT Consensus, Intensive Care Medicine 2012

**Table 4** Recommendations on ultrasound vascular access in adults and cost-effectiveness

| Ultrasound vascular access in adults | | | | |
|---|---|---|---|---|
| Domain code | Suggested definition | Level of evidence | Degree of consensus | Strength of recommendation |
| D4.SD2.S1 | Ultrasound guidance should be routinely used for short-term central venous access in adults | A | Very good | Strong |
| D4.SD2.S2 | Ultrasound guidance should be routinely used for long-term central venous access in adults | A | Very good | Strong |
| D4.SD2.S3 | PICCs should be routinely inserted at mid arm level by ultrasound guidance using micro introducer technique | A | Very good | Strong |
| D4.SD2.S4 | Use of ultrasound guidance should be taken into consideration for any kind of peripheral intravenous line when difficult access is anticipated | B | Very good | Strong |
| D4.SD2.S5 | Ultrasound-guided arterial catheterization improves first-pass success and should be used routinely in adults | A | Very good | Strong |
| D4.SD2.S6 | Ultrasound can accurately detect pneumothorax and should be routinely performed after central venous catheter cannulation when the pleura could have been damaged | B | Very good | Strong |
| D4.SD2.S7 | CEUS (contrast-enhanced ultrasound) is a valid method for detecting a central venous catheter tip in the right atrium | B | Very good | Strong |
| Cost-effectiveness of the use of ultrasound for vascular cannulation | | | | |
| D5.S1–3 | Ultrasound-guided vascular access has to be used because it results in clinical benefits and reduced overall costs of care makes it cost-effective | A | Very good | Strong |

WoCoVA-GAVeCeLT Consensus, Intensive Care Medicine 2012

EJA

*Eur J Anaesthesiol* 2020; **37:**344–376

GUIDELINES

# European Society of Anaesthesiology guidelines on peri-operative use of ultrasound-guided for vascular access (PERSEUS vascular access)

Massimo Lamperti, Daniele Guerino Biasucci, Nicola Disma, Mauro Pittiruti, Christian Breschan, Davide Vailati, Matteo Subert, Vilma Traškaitė, Andrius Macas, Jean-Pierre Estebe, Regis Fuzier, Emmanuel Boselli and Philip Hopkins

European Society of Anaesthesiology ESA

EJA

*Eur J Anaesthesiol* 2020; **37**:344–376

2020

GUIDELINES

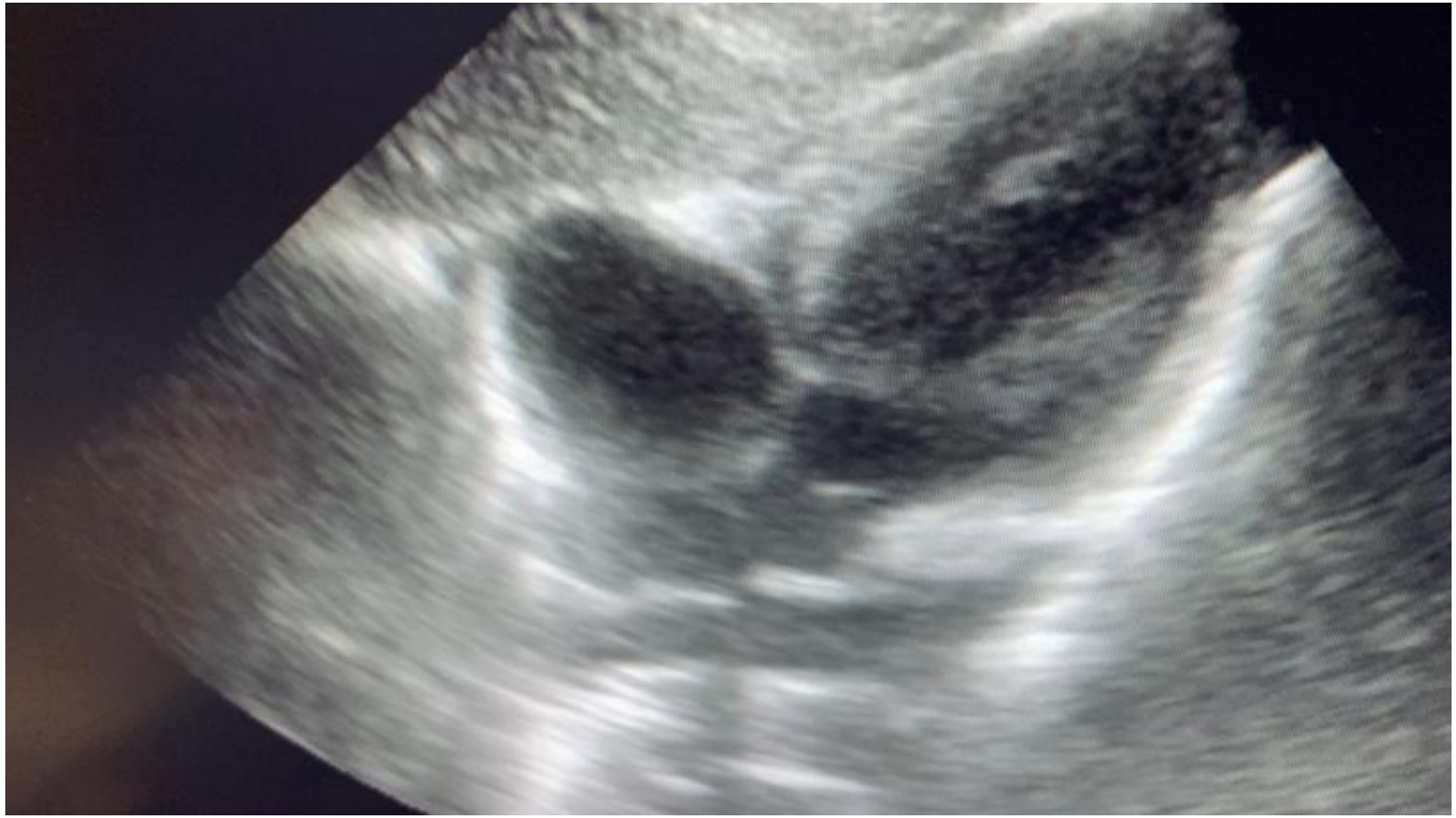
# European Society of Anaesthesiology guidelines on peri-operative use of ultrasound-guided for vascular access (PERSEUS vascular access)

When an intracavity electrocardiogram is not applicable, we recommend using real-time ultrasound to detect and prevent central venous catheter malposition, as it has been shown to be well tolerated, feasible, quickly performed and interpreted at the bedside, and it is more accurate and faster than chest radiograph (**1C**).

# Contrast-enhanced ultrasound (CEUS)

- **Simple saline**
  - neonates
- **Saline + microbubbles of air (‘shakered saline’)**
  - children and adults

**so-called ‘bubble test’**



# US-BASED TIP LOCATION (bubble test)

**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

# The latest clinical study

*Original research article*

JVA | The Journal of Vascular Access

## Transthoracic echocardiography as bedside technique to verify tip location of central venous catheters in patients with atrial arrhythmia

The Journal of Vascular Access
1–7

DOI: 10.1177/1129729820905200
journals.sagepub.com/home/jva
SAGE

Emanuele Iacobone[1], Daniele Elisei[1], Diego Gattari[1], Luigi Carbone[1] and Giuseppe Capozzoli[2]

2020

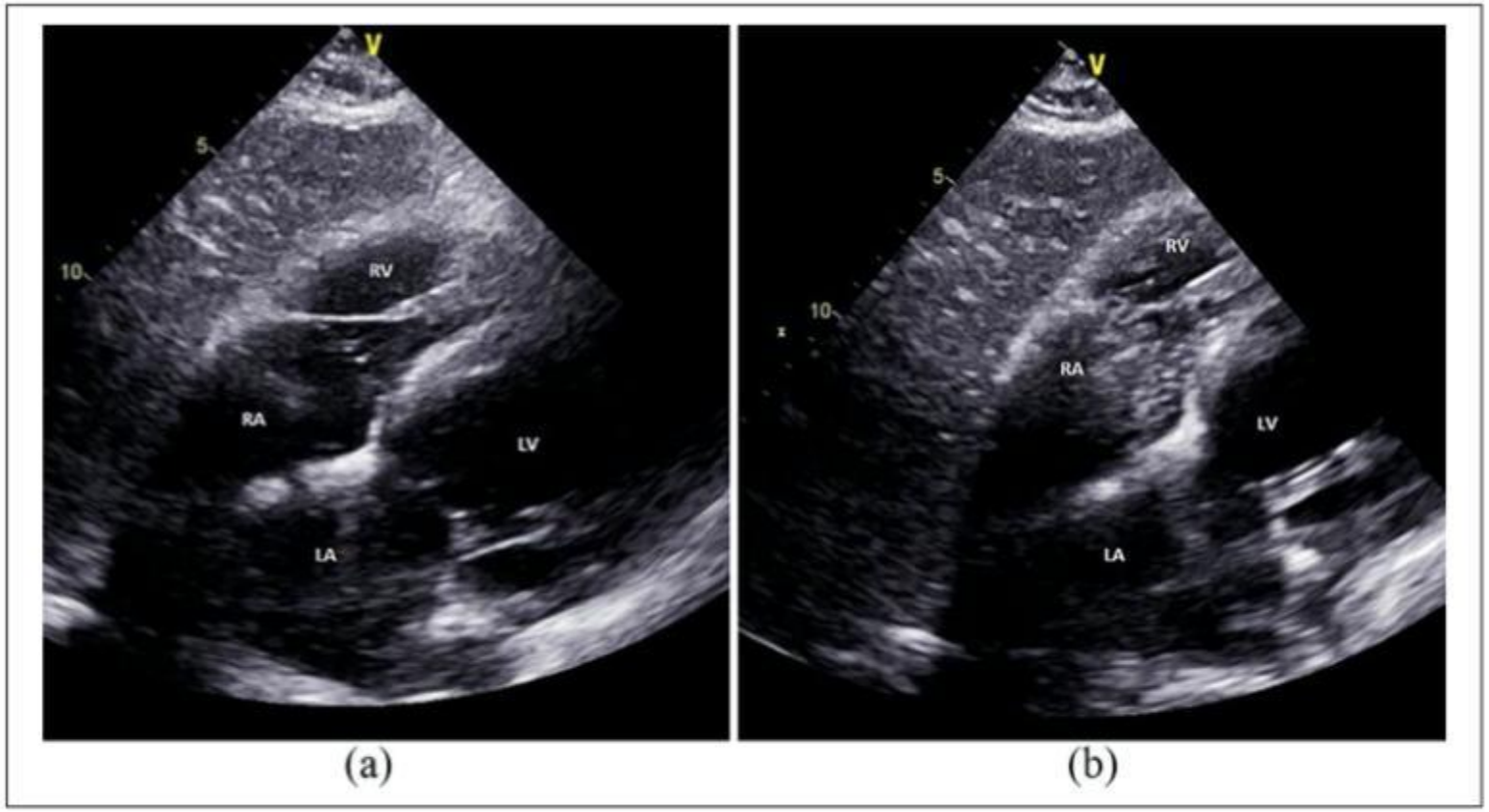
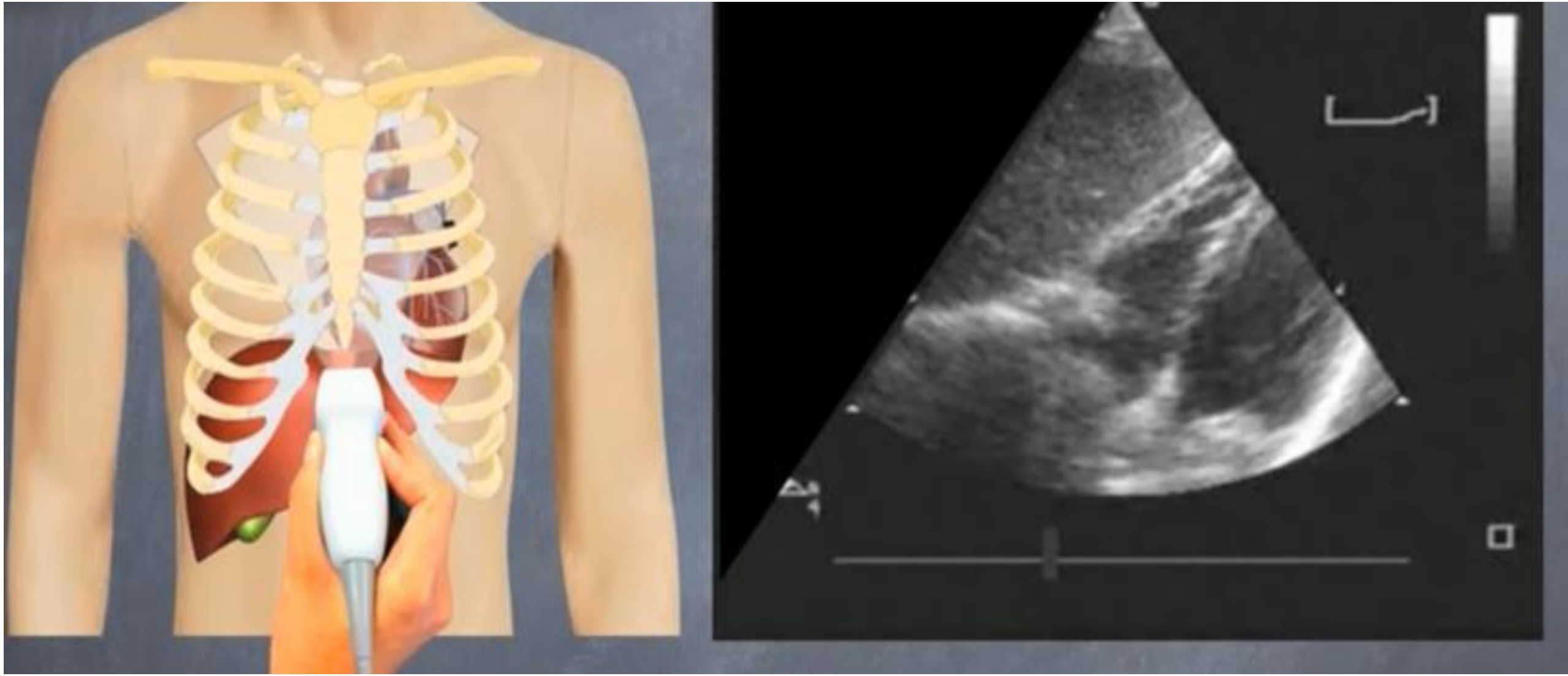


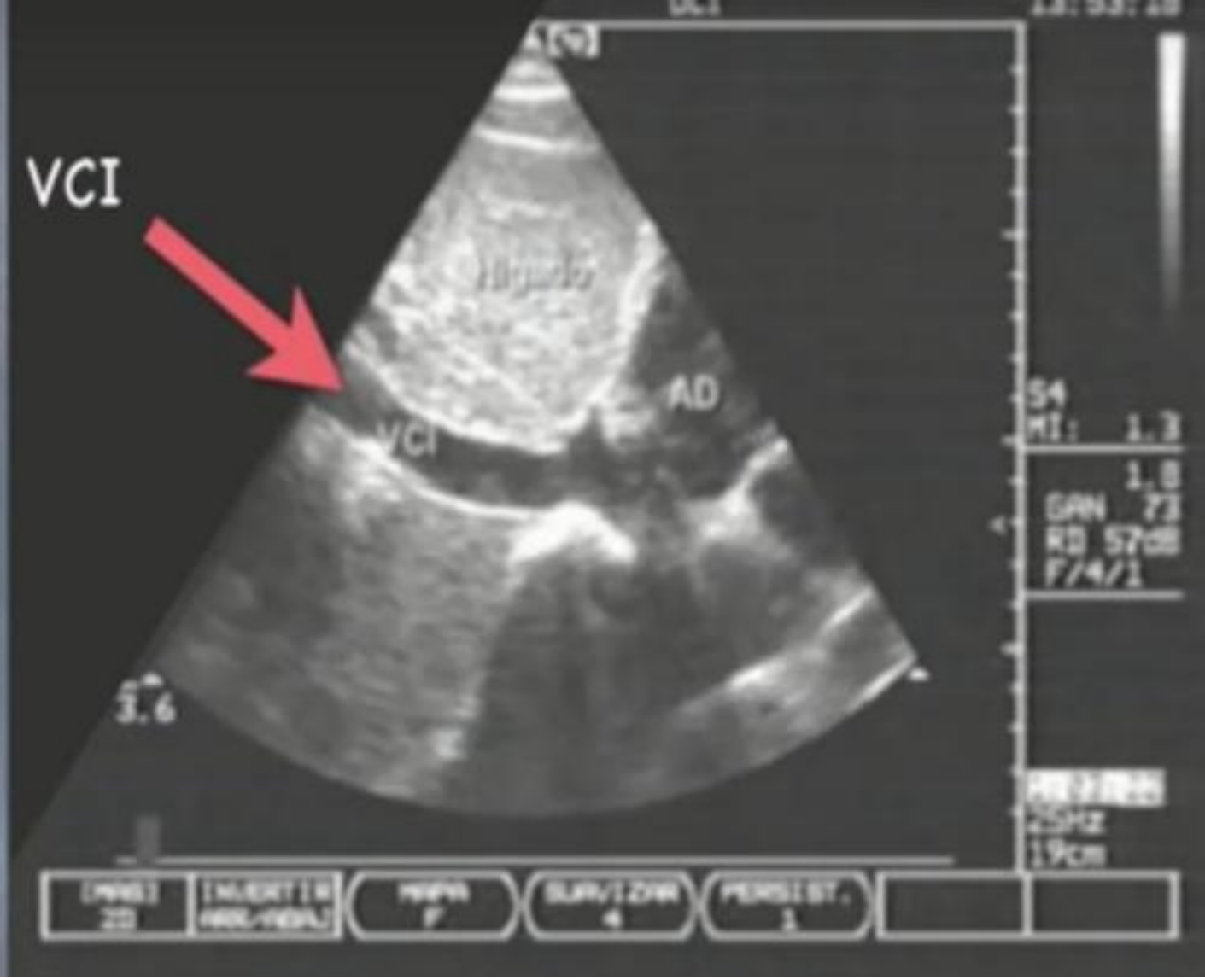

**Figure 1.** (a) Subcostal four-chamber view showing left atrium, left ventricle, right atrium (RA), right ventricle (RV) and (b) visualization of the bubble effect within the RA, leading into the RV in subcostal four-chamber view during saline flush injection.

# SUBCOSTAL VIEW

# SUBCOSTAL VIEW



## Subcostal four-chamber view




# Subcostal bicaval view

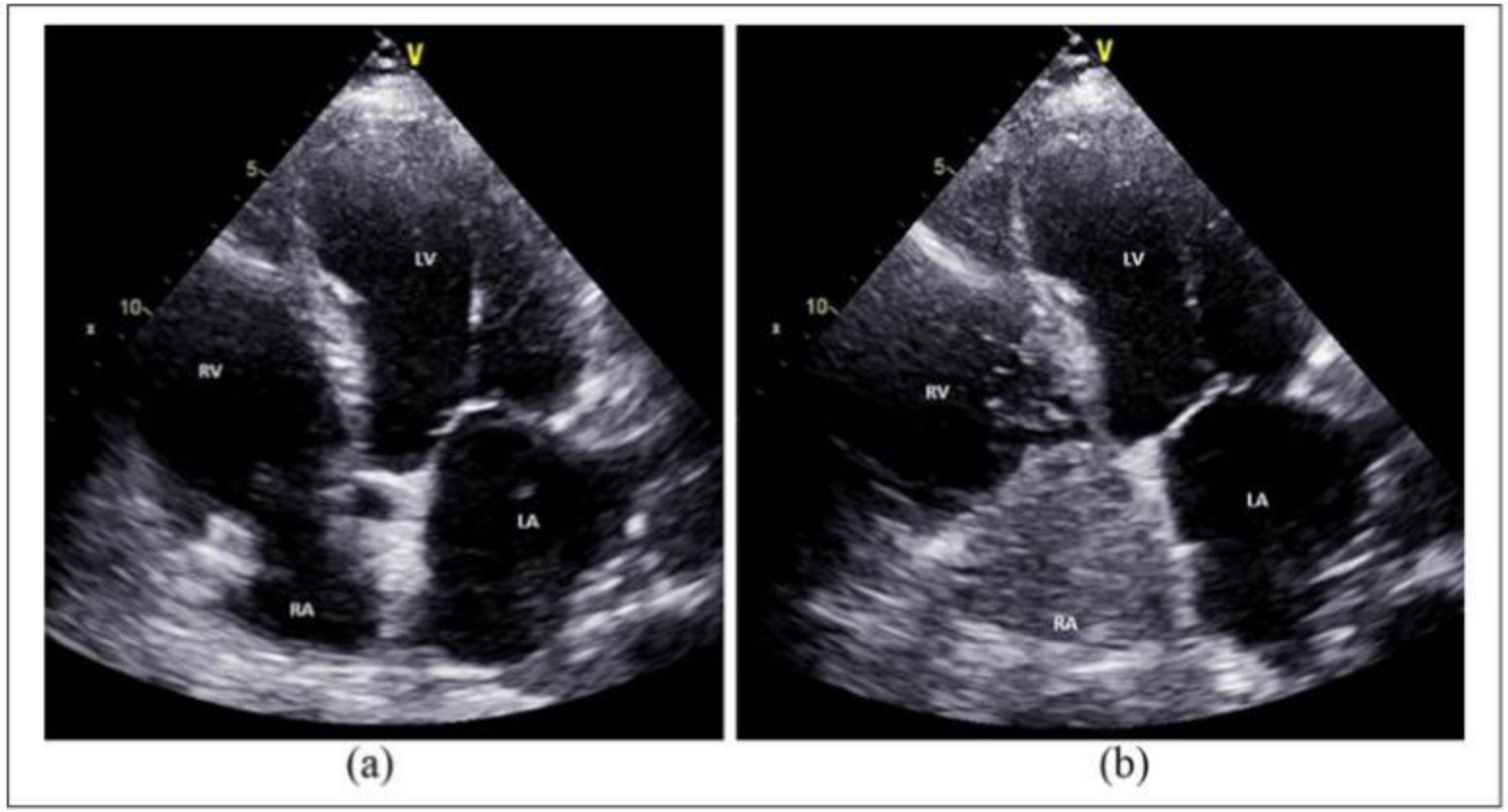
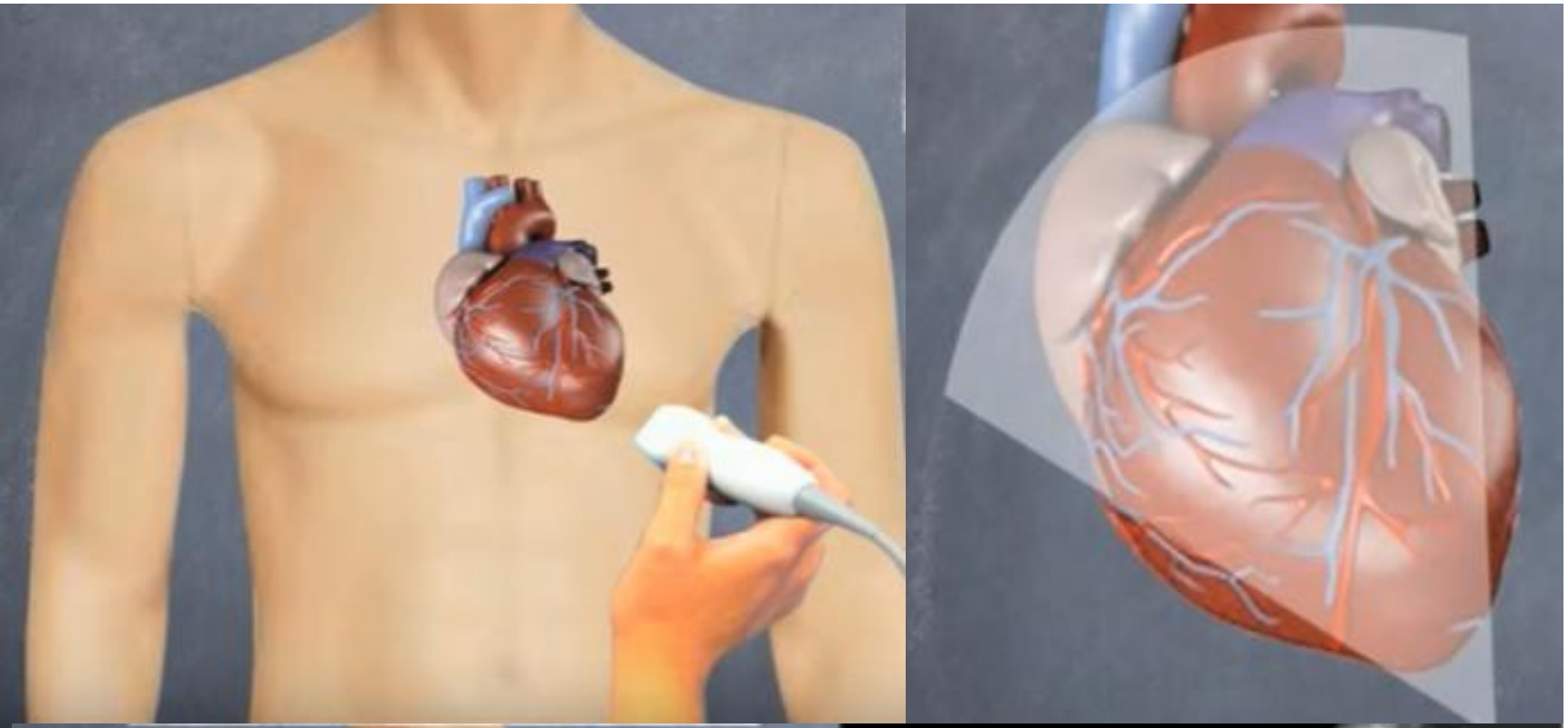



**Figure 2.** (a) Apical four-chamber view showing left atrium, left ventricle, right atrium (RA), right ventricle (RV) and (b) visualization of the bubble effect within the RA in apical four-chamber view during saline flush injection.

# APICAL VIEW

# APICAL VIEW



# Apical view

# Tip location by TTE in pediatrics

- Particularly easy in **children**
  - PICC, CICC, FICC, port, etc.

- Ideal in **neonates** and **infants**
  - UVC, ECC, CICC, FICC

**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)**

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

**Francesca Rossetti[1], Mauro Pittiri[2], Massimo Lamperti[3], Ugo Graziano[4], Davide Celentano[5], Giuseppe Capozzoli[6]**

[1] Department of Anesthesia, Children's Hospital 'Meyer', Firenze - Italy
[2] Department of Surgery, Catholic University Hospital, Roma - Italy
[3] Department of Neuroanesthesia, Neurological Institute 'Besta', Milano - Italy
[4] Department of Surgery, Children's Hospital 'Santobono', Napoli - Italy
[5] Pediatric Intensive Care Unit, Catholic University Hospital, Roma - Italy
[6] Department of Anesthesia and Intensive Care, Ospedale Civile di Bolzano, Bolzano - Italy

2015

**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)

2015

JVA
ISSN 1129-7298

J Vasc Access 2015; 16 (2): 130-136
DOI: 10.5301/jva.5000314

ORIGINAL ARTICLE

## Central venous access devices in pediatric malignancies: a position paper of Italian Association of Pediatric Hematology and Oncology

Alessandro Crocoli[1], Assunta Tornesello[2], Mauro Pittiruti[3], Angelica Barone[4], Paola Muggeo[5], Alessandro Inserra[1], Angelo Claudio Molinari[6], Valeria Grillenzoni[7], Viviana Durante[8], Maria Pia Cicalese[9], Giulio Andrea Zanazzo[10], Simone Cesaro[7]

[1] General and Thoracic Surgery Unit, Department of Surgery, Bambino Gesù Children's Hospital, IRCCS, Rome - Italy
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[9] Pediatric Immunology and Bone Marrow Transplantation Unit, San Raffaele Telethon Institute for Gene Therapy (HSR-TIGET), "San Raffaele" Scientific Institute, Milan - Italy
[10] Institute for Maternal and Child Health, IRCCS "Burlo Garofolo", Trieste - Italy

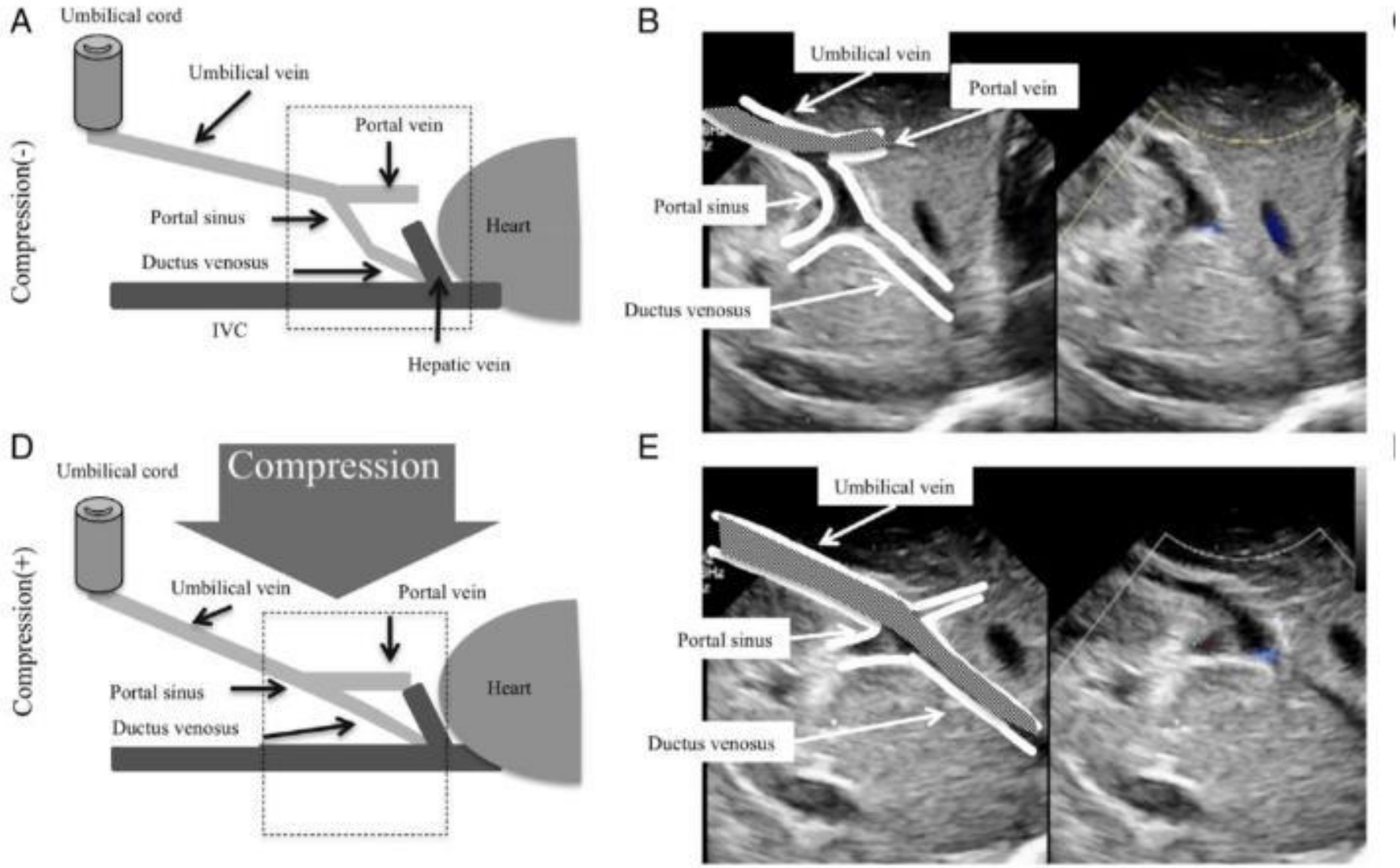
**«The tip location should be ideally verified in real time during the procedure (by fluoroscopy, by intracavitary electrocardiography or by echocardiography) or — as a second option — soon after the procedure (by chest x-ray or by echocardiography)».**

**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).**

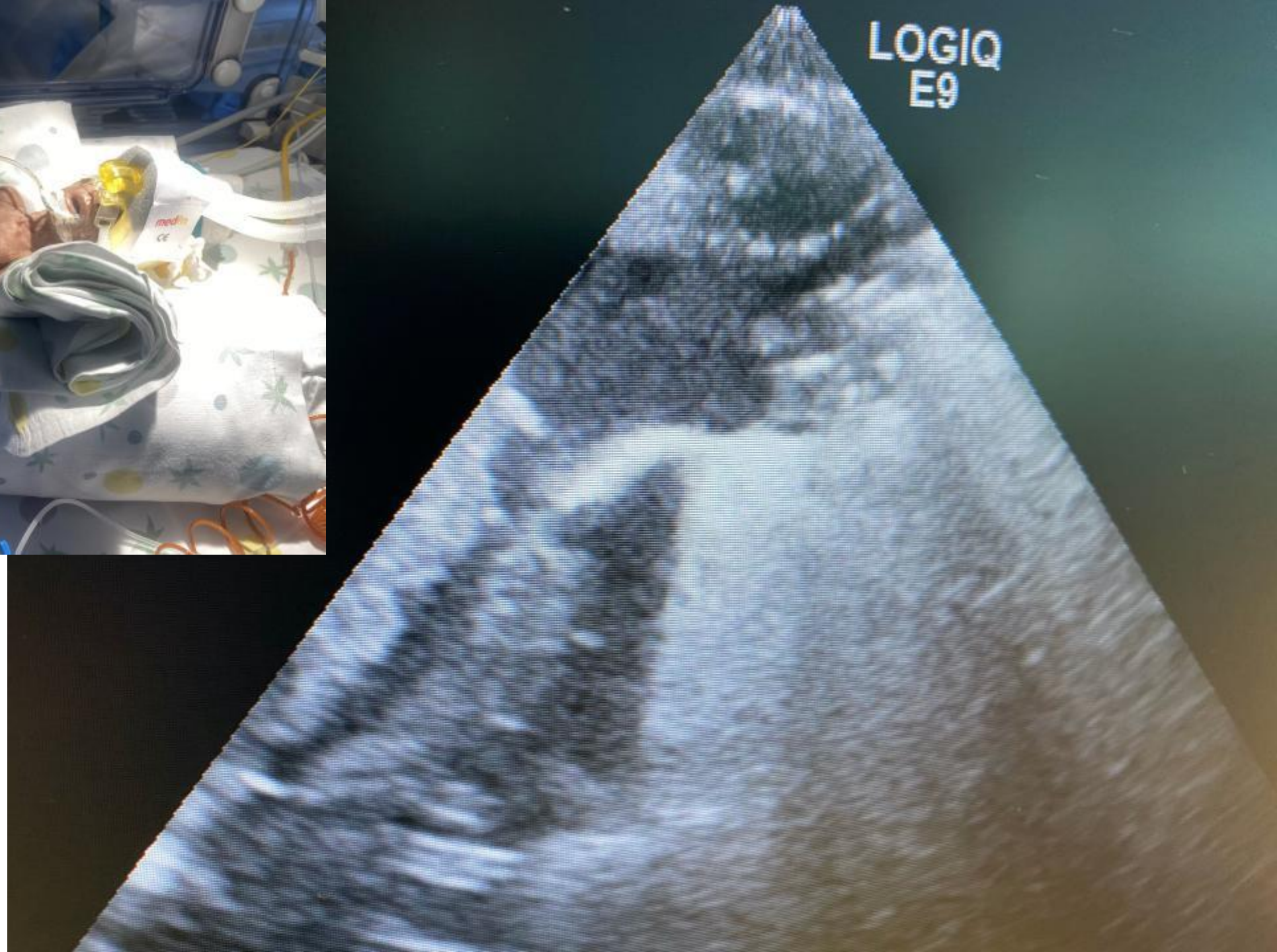
**As ultrasound-based tip location by TTE is particularly easy and accurate for ECC and UVC in neonates, and it is becoming more popular than IC-ECG.**

**For CICCs = or > 3Fr in neonates and for all central lines in children, on the other hand, IC-ECG is still the ideal tip location method.**

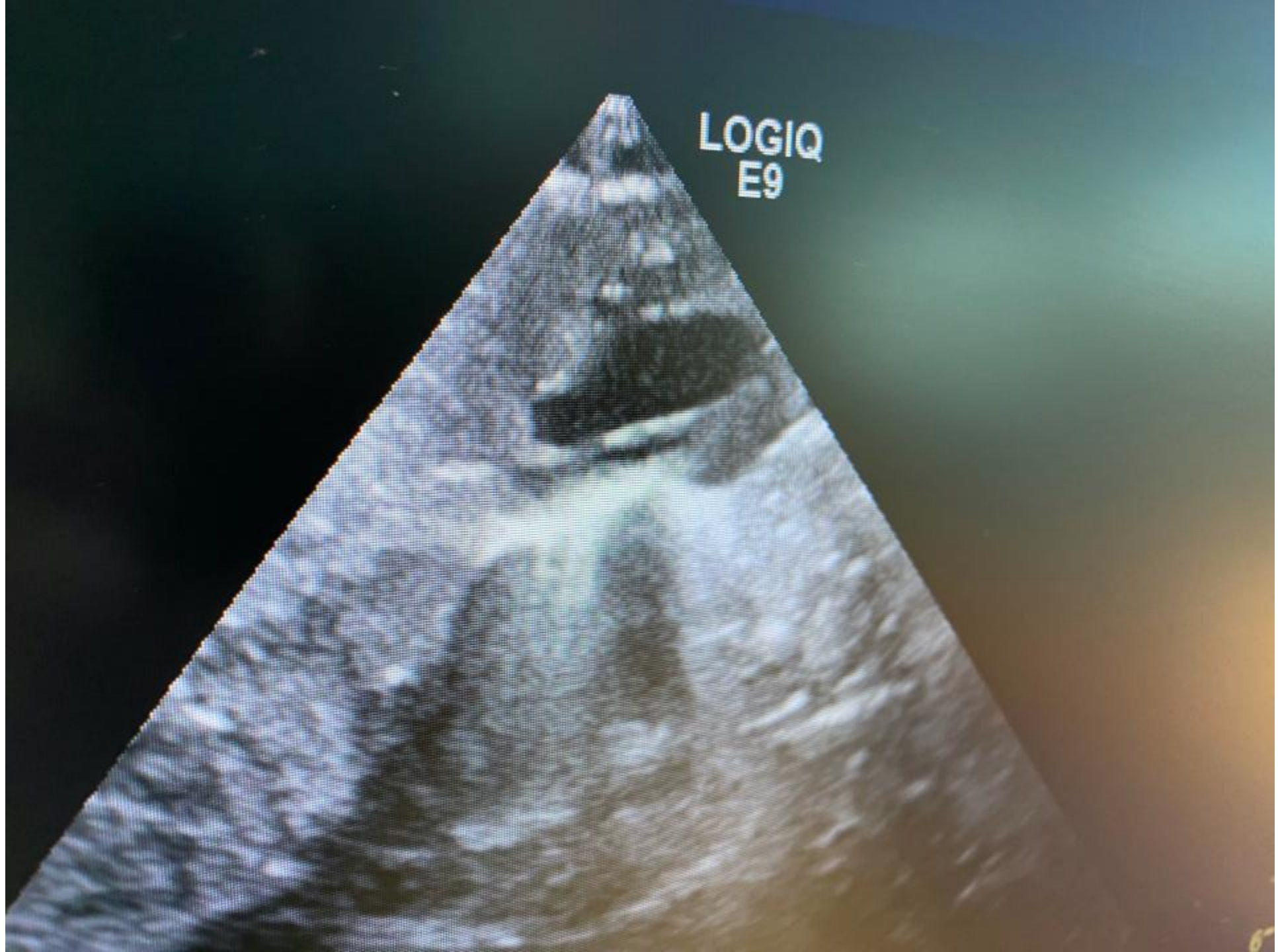
# TTE for umbilical venous catheters




*Kishigami et al. Ultrasound-Guided Umbilical Venous Catheter Insertion With Alignment of the Umbilical Vein and Ductus Venosus. J of ultrasound Medicine 2019*




**TTE for epicutaneo-cava catheters**


LOGIQ
E9

# Today, 2020: trans-thoracic echocardiography (TTE) is an appropriate method for intra-procedural tip location

- Accurate
  - More accurate than radiology
  - Less accurate than IC-ECG or TEE
- Inexpensive
  - Less expensive than radiology or TEE
  - As inexpensive as IC-ECG
- 100% Safe
  - Safer than radiology or TEE
  - As safe as IC-ECG
- Easy to perform
  - Easier than radiology or TEE
  - As easy as IC-ECG
- Easy to learn
  - Easier than radiology or TEE
  - Less easy than IC-ECG

# TTE

Accurate

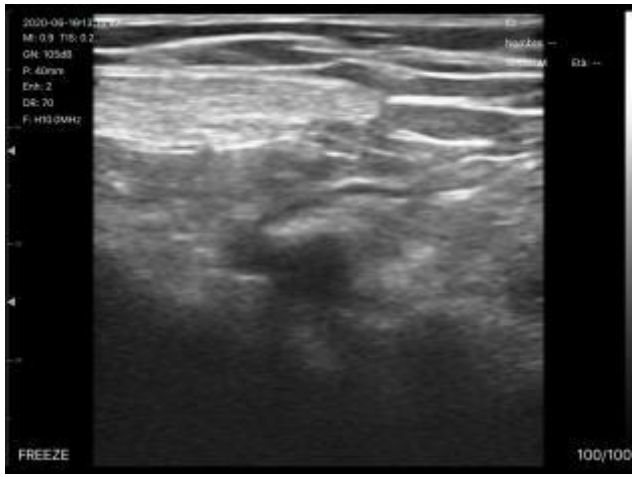
Inexpensive

Safe

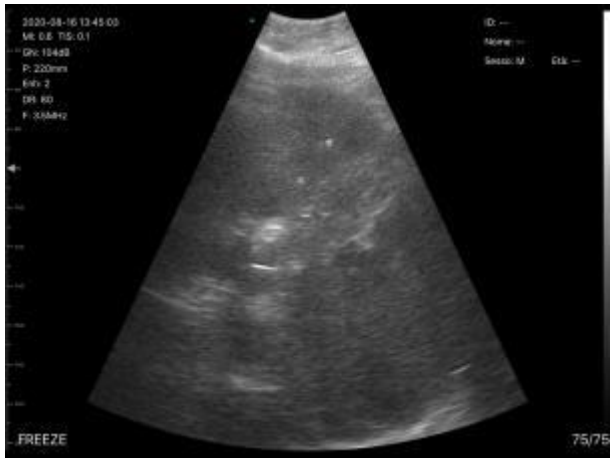
Easy

**ONE WIRELESS PROBE FOR ALL USES**

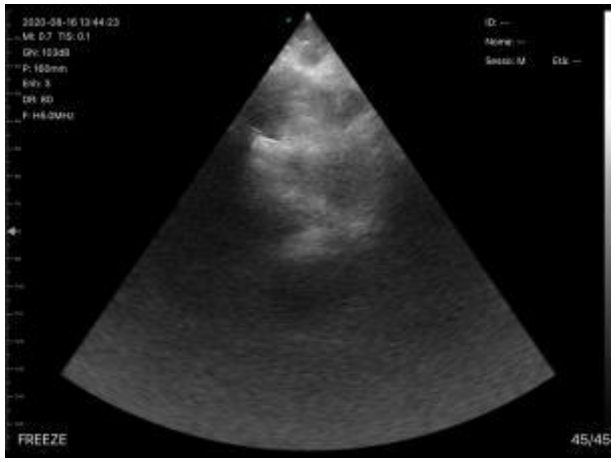

## LINEAR PROBE




## CONVEX PROBE




## SECTOR PROBE







LINEAR PROBE

## ONE WIRELESS PROBE FOR ALL USES:

1) US-guided venipuncture for PICC
2) US-guided venipuncture for CICC
3) Detection of pneumothorax (pleural scan)
4) Tip navigation (supraclavicular scan)
5) Tip location (subcostal view)
6) Tip location (apical view)



CONVEX OR SECTOR PROBE

# In conclusion, TTE has proper indications:

Recommended for all central VADs in neonates

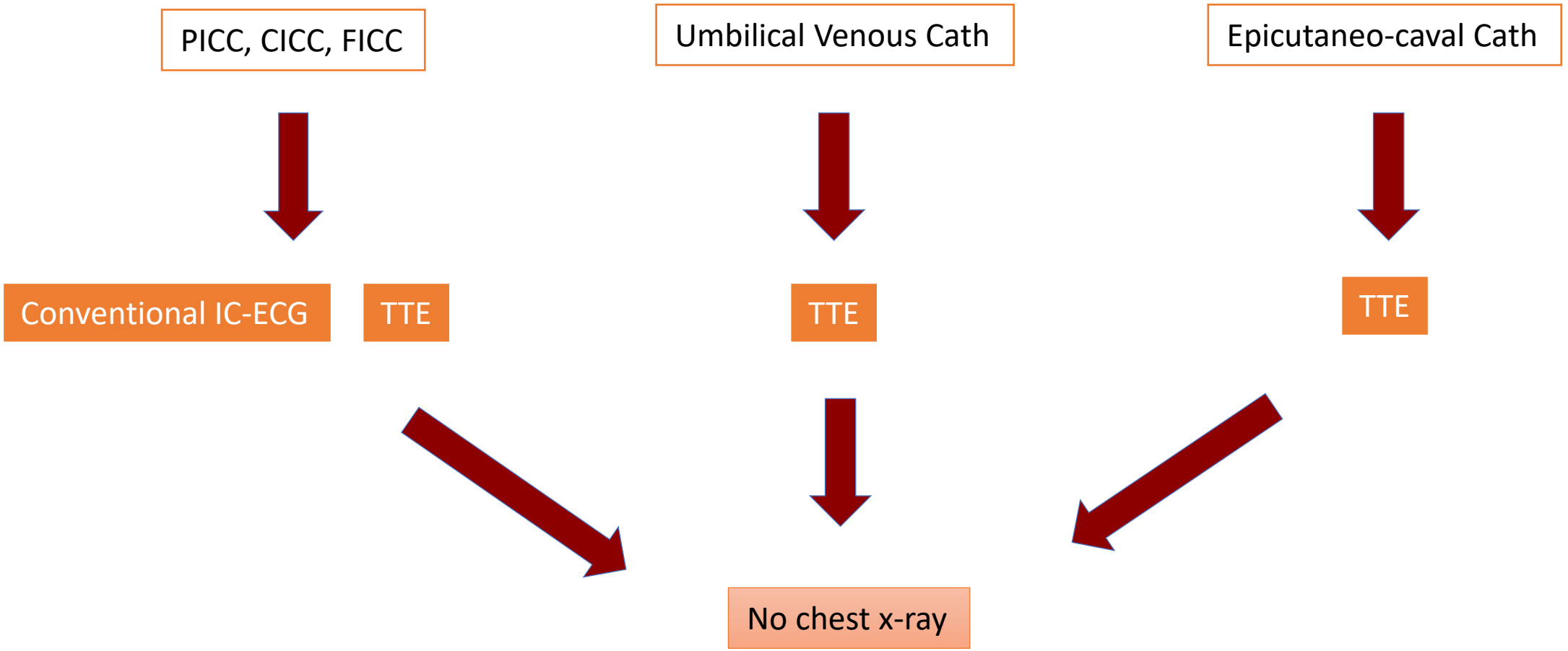
- particularly easy, accurate and always feasible

Not ideal for routine use in adults and children, **but appropriate when conventional IC-ECG or modified IC-ECG are not applicable or not feasible: no P; no AF; emergency (!)**

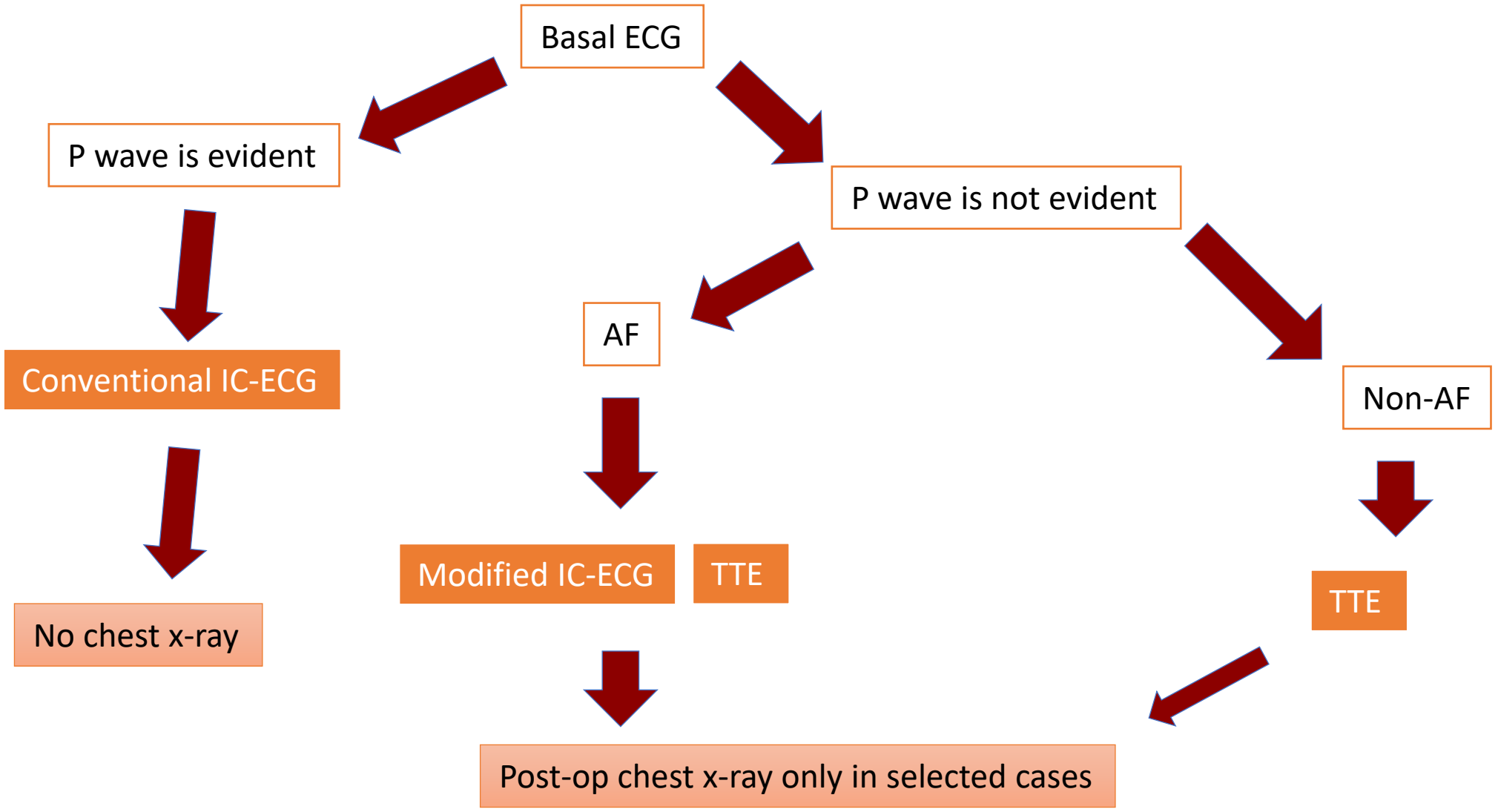
- not as accurate as IC-ECG
- not always easy or feasible
- requires training

# Conclusions

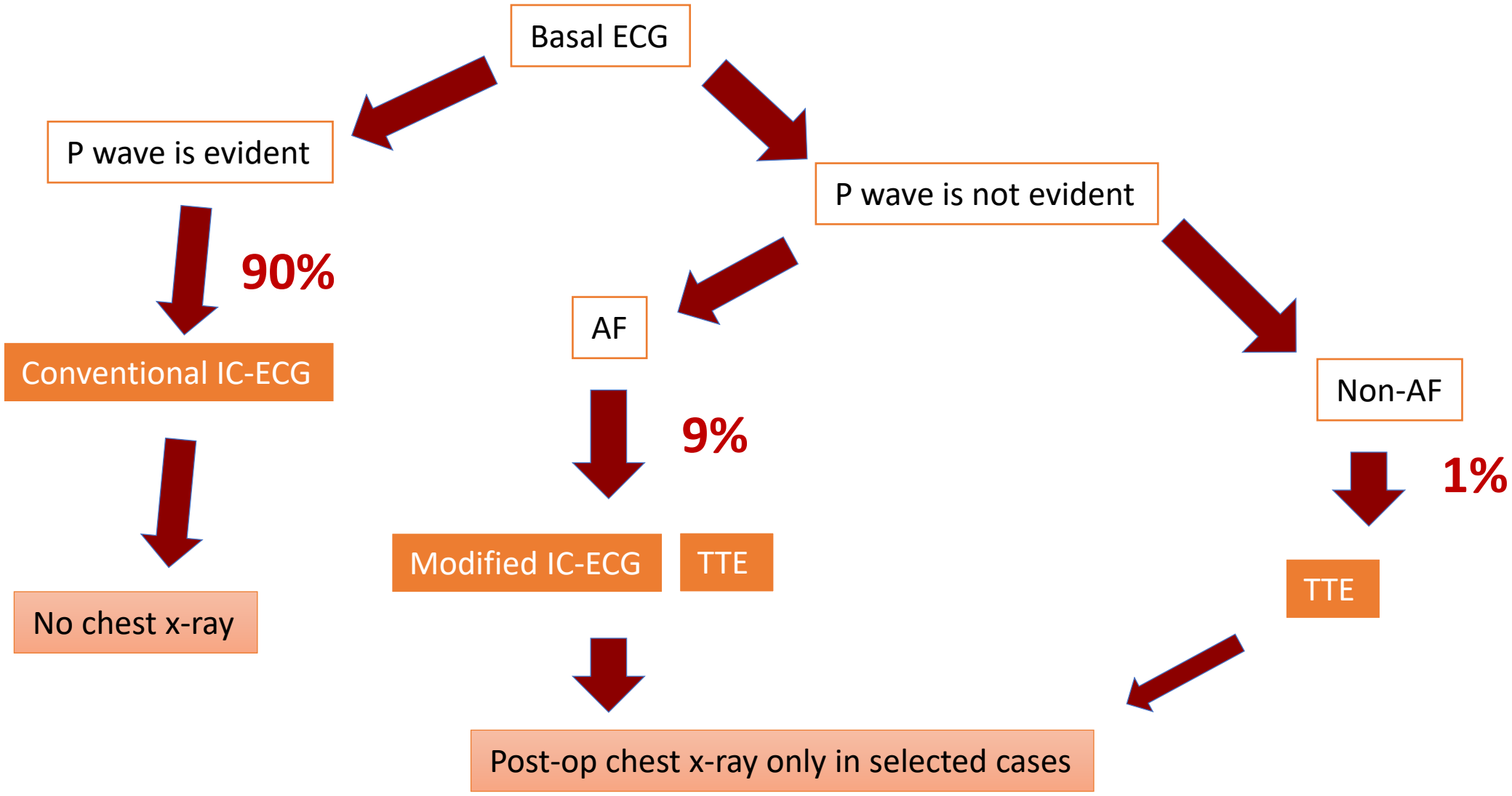
# Our current algorithm in neonates and children



# Our current algorithm in adults



# Our current algorithm in adults



# Take home messages

1) **Use ALWAYS an intraprocedural method**

   'blind' insertion by length estimation only + post-procedural x-ray is simply not acceptable any more

2) **Avoid fluoroscopy**

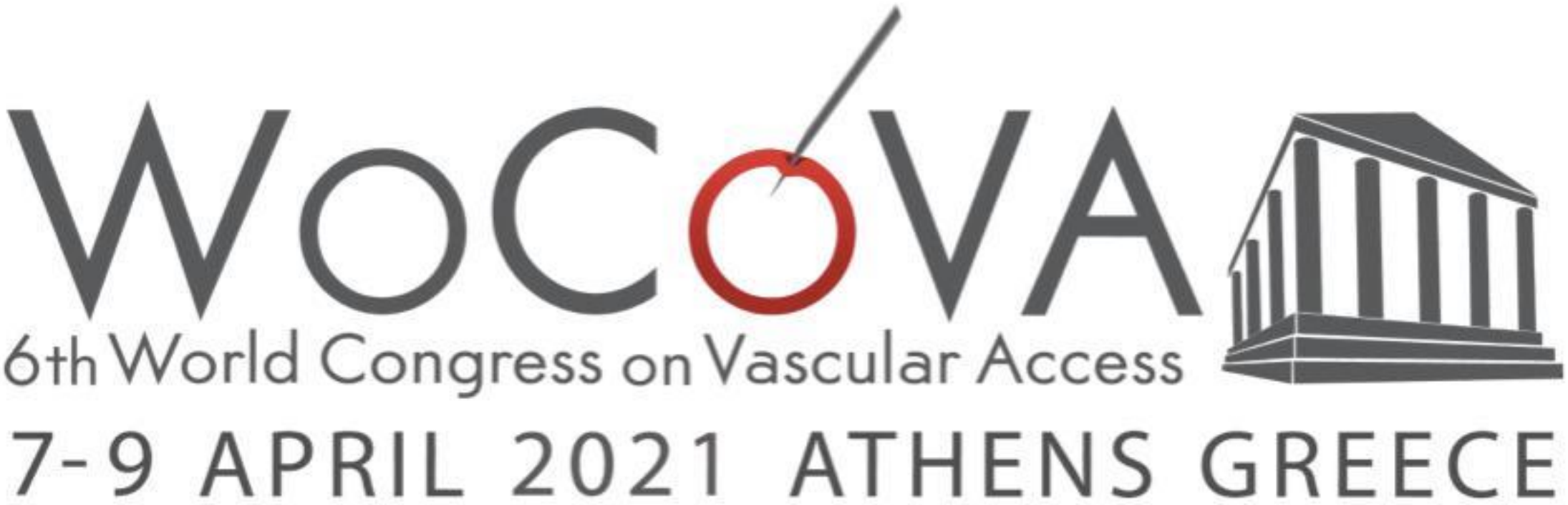
   It is expensive, inaccurate and unsafe: its routine use is not acceptable any more

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 only in selected cases*

# SAVE THE DATE !



# Thank you for your attention

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