Tip location in atrial fibrillation

Antonio La Greca
Università Cattolica – Policlinico “A. Gemelli”
Roma

X PICC DAY

Roma 2016
Auditorium del Massimo
Mercoledì 30 Novembre

Riunione monotematica annuale dedicata ai PICC e ai Midline

Disclosure

- None

WoCoVA
World Congress Vascular Access

Tip location: during CVC insertion !!!


Clinical Nutrition 28 (2009) 365–377

Contents lists available at ScienceDirect

Clinical Nutrition

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

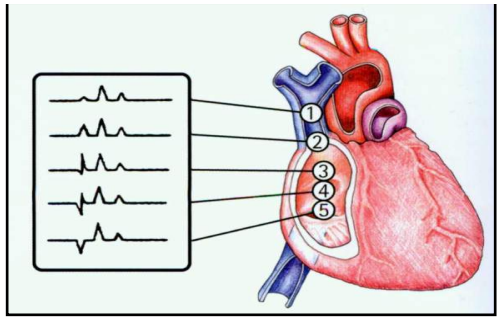
ESPEN Guidelines on Parenteral Nutrition: Central Venous Catheters (access, care, diagnosis and therapy of complications)

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

"Ideally, the position of the tip should be checked ***during*** the procedure"

"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"

Intraprocedural tip location: IC-ECG



Intracavitary ECG is a well established method for verifying the position of the tip of a CVC

J Vasc Access 2011; 12 (4): 280-291
DOI: 10.5301/JVA.2011.8381
REVIEW

The electrocardiographic method for positioning the tip of central venous catheters

Mauro Pittiruti[1], Antonio La Greca[1],

J Vasc Access 2012; 13 (3): 357-365
DOI: 10.5301/JVA.2012.9020
ORIGINAL ARTICLE

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

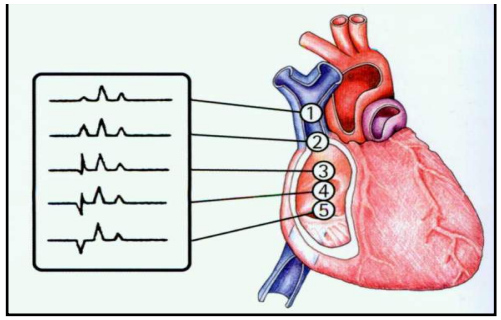
Mauro Pittiruti[1], Daniele Bertollo[2], Ermanno Briglia[3], Massimo Buononato[4], Giuseppe Capozzoli[5], Luigi De Simone[6], Antonio La Greca[1],

JVA
ISSN 1129-7298
J Vasc Access 2015; 16 (2): 137-143
DOI: 10.5301/jva.5000281
ORIGINAL ARTICLE

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 Pittiruti[2], Massimo Lamperti[3], Ugo Graziano[4], Davide Celentano[5], Giuseppe Capozzoli[6]

Tip location: IC-ECG

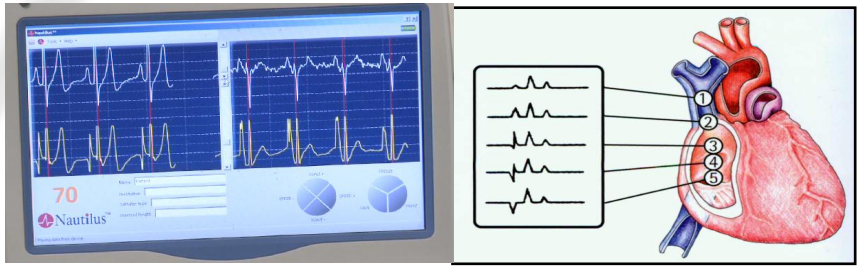


	Adults*	Children**
Accuracy	94.5%	95.8%
Feasibility	98.5%	99.3%

*The intracavitary ECG method for positioning the tip of central venous catheters: results of an Italian multicenter study. M Pittiruti et al J Vasc Access 2012;13 (3): 357-365

** The intracavitary ECG method for positioning the tip of central venous devices in pediatric patients: a multicenter study. F. Rossetti, M. Pittiruti et al. J Vasc Access, IN PRESS

IC-ECG: guidelines !!!



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]

of malposition may be minimized by using a technique for intra-operative control of the position of the catheter tip (including fluoroscopy and ECG-based methods).

Ideally, the position of the tip should be checked during the procedure,[27] either by fluoroscopy or by the ECG method.[28,29] If the

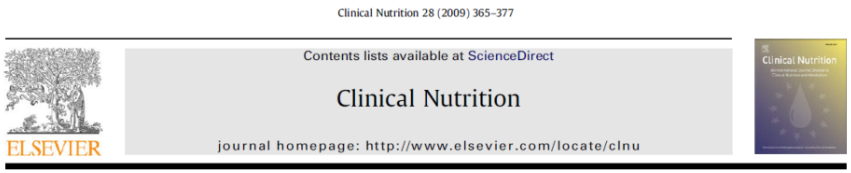
Not only as as an alternative to X-Ray based controls ...

E. 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. Follow manufacturers' directions for use with other ECG-based technology using a changing light pattern to detect tip location.

... but even as a first-choice method

No more X-Rays


Clinical Nutrition 28 (2009) 365–377

Contents lists available at ScienceDirect

Clinical Nutrition

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

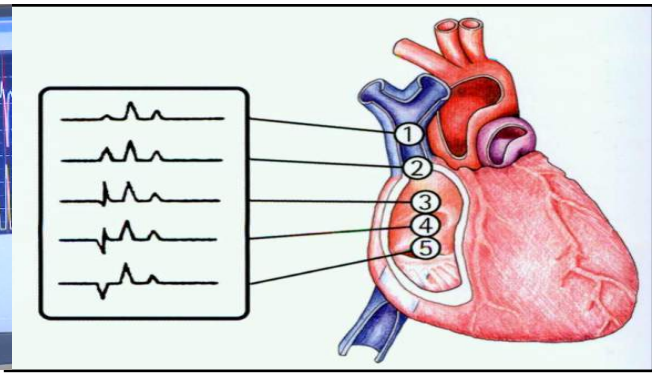
ESPEN Guidelines on Parenteral Nutrition: Central Venous Catheters (access, care, diagnosis and therapy of complications)

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

If the position has not been checked intraoperatively, a post-procedural chest X-ray should be performed to check the position of the tip

Postprocedure radiograph imaging is not necessary if alternative tip location technology confirms proper tip placement (II).

TIP LOCATION 2011-2016

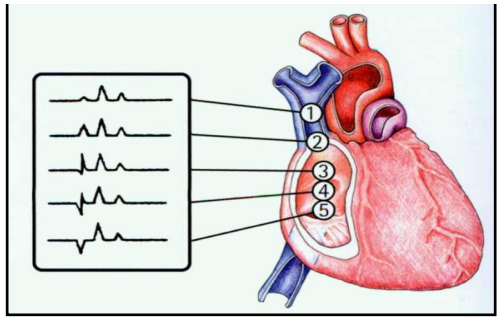


Standard of care: IC-ECG …

E. 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. Follow manufacturers' directions for use with other ECG-based technology using a changing light pattern to detect tip location.

Problem …



IC-ECG is based on the interpretation of changes of the p-wave during intracavitary detection of ECG:

- maximal p-wave = CAJ

Conventional IC-ECG cannot be carried out when the p-wave is:

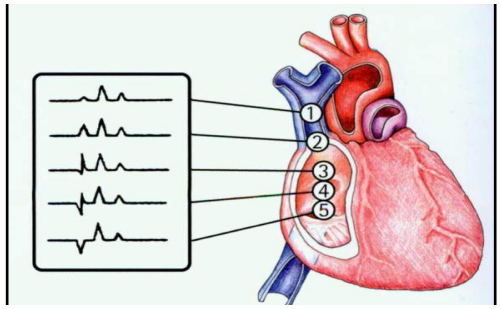
- absent (atrial fibrillation);
- abnormal (ectopic rhytms)
- hidden (active pacemakers)

Un-Applicability

- difficult to identify/evaluate (extreme tachycardia, malposition)

Un-Feasibility

Problem …

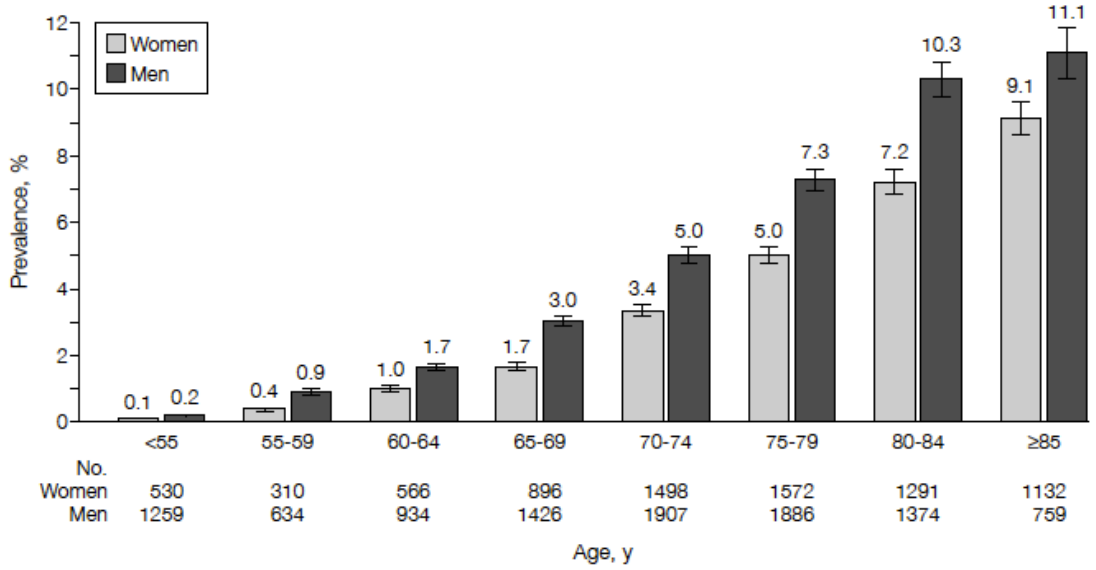


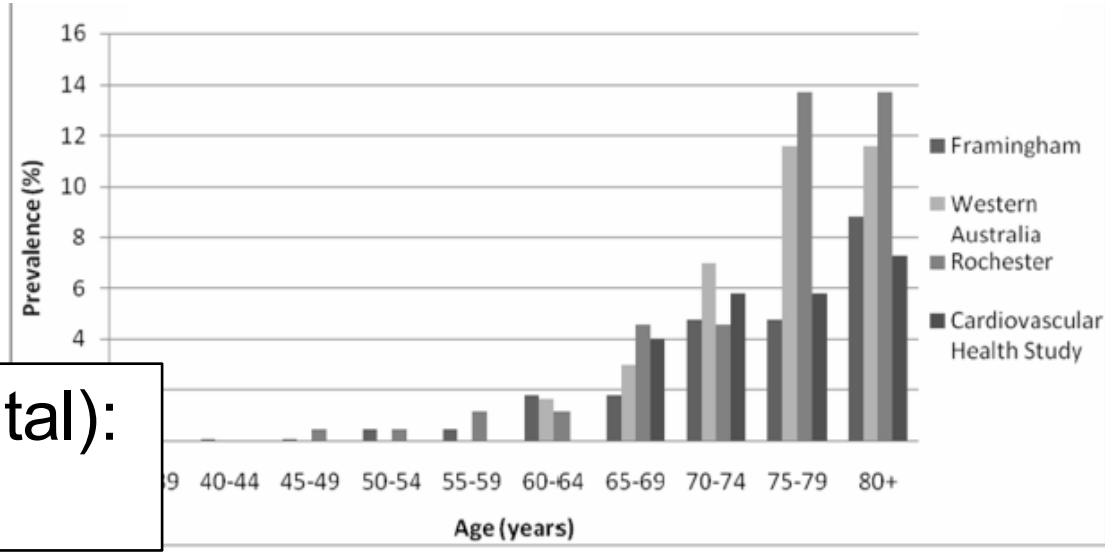
A subgroup of patients cannot benefit from IC-ECG:

a) Patients without an evident P wave or with abnormal P on their basal surface ECG tracking

- atrial fibrillation or other morphologic abnormalities of p wave (junctional rhythms and others)
- Active atrial pace-makers

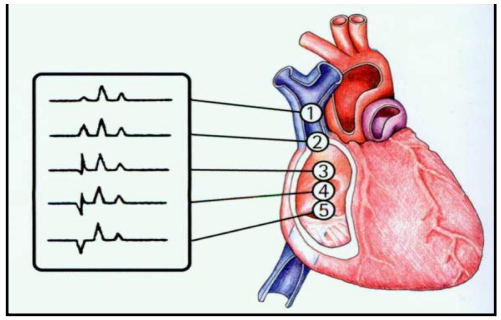
Figure 2. Prevalence of Diagnosed Atrial Fibrillation Stratified by Age and Sex





Global **applicability** (in-hospital): 91-93%

Problem …



A subgroup of patients cannot benefit from IC-ECG:

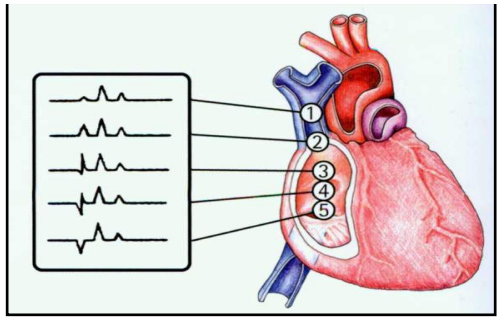
b) Difficult interpretation of a potentially detectable IC p-wave

- training ? correct procedural flow
- technical problems (electrical interference, cable or monitor quality)
- tachyarrythmias ?
- trembling or non cohoperating patients

c) No p-waves variations detected despite potentially detectable IC p-wave

Global **feasibility**
(italian multicenter studies)
98.5-99.3%

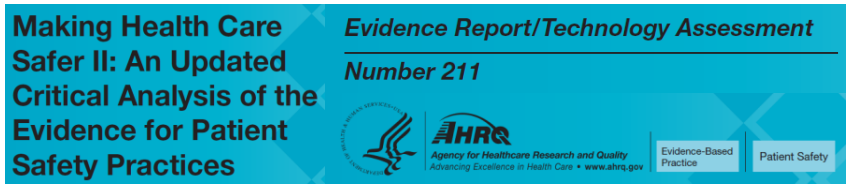
Problem …



2. Assess patient for known history of cardiac dysrhythmias and the presence of a P wave on ECG (if available) before planning to use ECG technology for placement. Contraindications to the use of ECG technology include patients with an abnormal ECG rhythm with an absence or alteration in the P wave (eg, presence of pacemakers, atrial fibrillation, extreme tachycardia). Follow manufacturers' directions for use in the appropriate patient populations.

No more X-Rays

We still want to strictly adhere to the 2013 AHRQ statement



Annals of Internal Medicine | SUPPLEMENT

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

Annals of Internal Medicine

March 2013 | Annals of Internal Medicine | Volume 158 • Number 5 (Part 2) | 365

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

Intra-procedural tip location in the IC-ECG unsuitable patients: how ?

- Introducing alternative tip location methods
- Adding further tip location and/or navigation technologies to IC-ECG
- Improving applicability of IC-ECG (modified IC-ECG)
- Integrating all the above mentioned strategies (an algorithm)

Intra-procedural tip location in the IC-ECG unsuitable patients: how ?

- Introducing alternative tip location methods

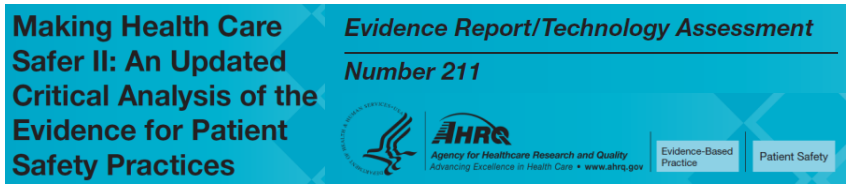
Intra-procedural tip location in the IC-ECG unsuitable patients: how ?

- Introducing alternative tip location methods
  - Fluoroscopy
  - Echocardiography
    - Trans-esophageal
    - Trans-thoracic
  - Modified IC-ECG

Intra-procedural tip location: Fluoroscopy

- Expensive
- Logistically unsustainable
- Inaccuracy of radiological landmarks

Intra-procedural tip location: Fluoroscopy



Annals of Internal Medicine | SUPPLEMENT

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

Annals of Internal Medicine

March 2013 | Annals of Internal Medicine | Volume 158 • Number 5 (Part 2) | 365

Encouraged

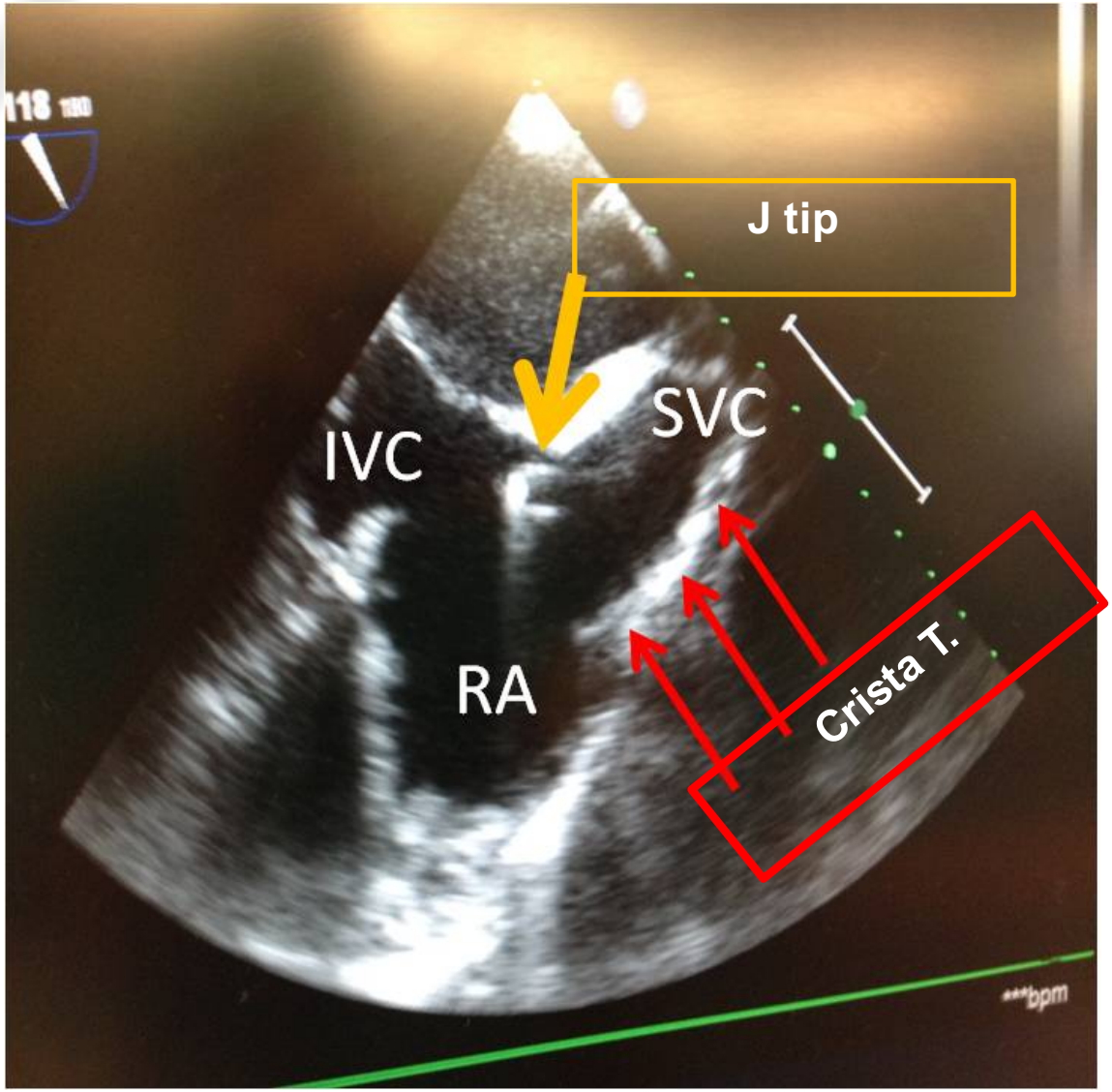
- Multicomponent interventions to reduce falls
- Use of clinical pharmacists to reduce adverse drug events
- Documentation of patient preferences for life-sustaining treatment
- Obtaining informed consent to improve patients' understanding of the potential risks of procedures
- Team training
- Medication 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

Intra-procedural tip location: Fluoroscopy

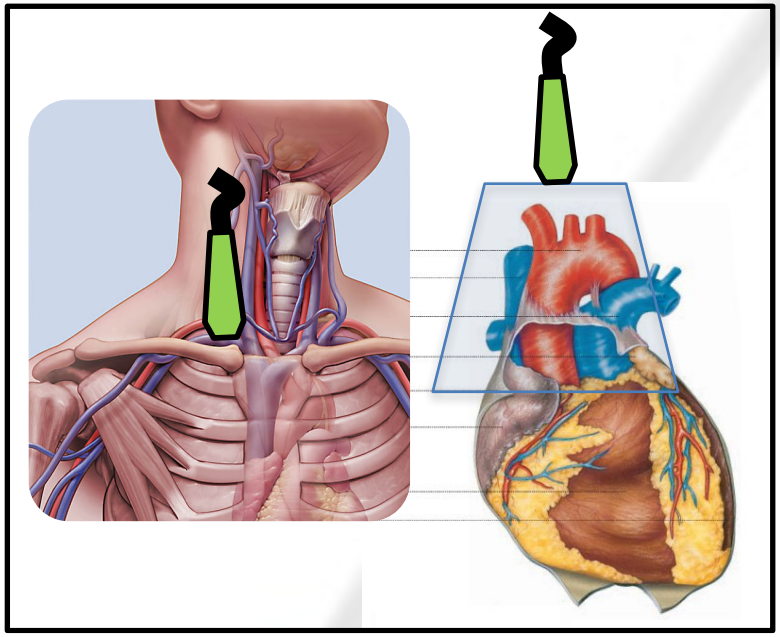
4. Avoid fluoroscopy except in the case of difficult CVAD insertions, as it requires exposure to ionizing radiation.

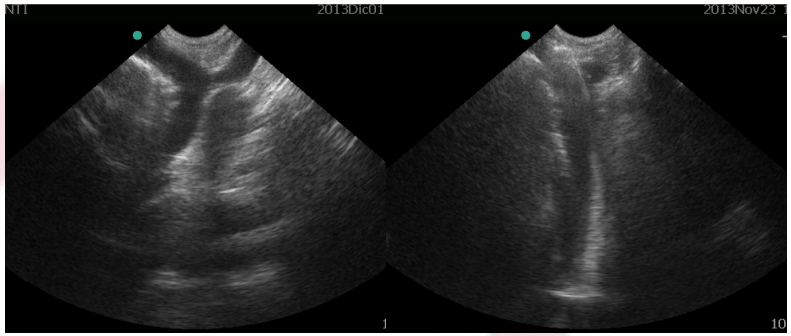
Intra-procedural tip location: Trans-Esophageal Echocardiography

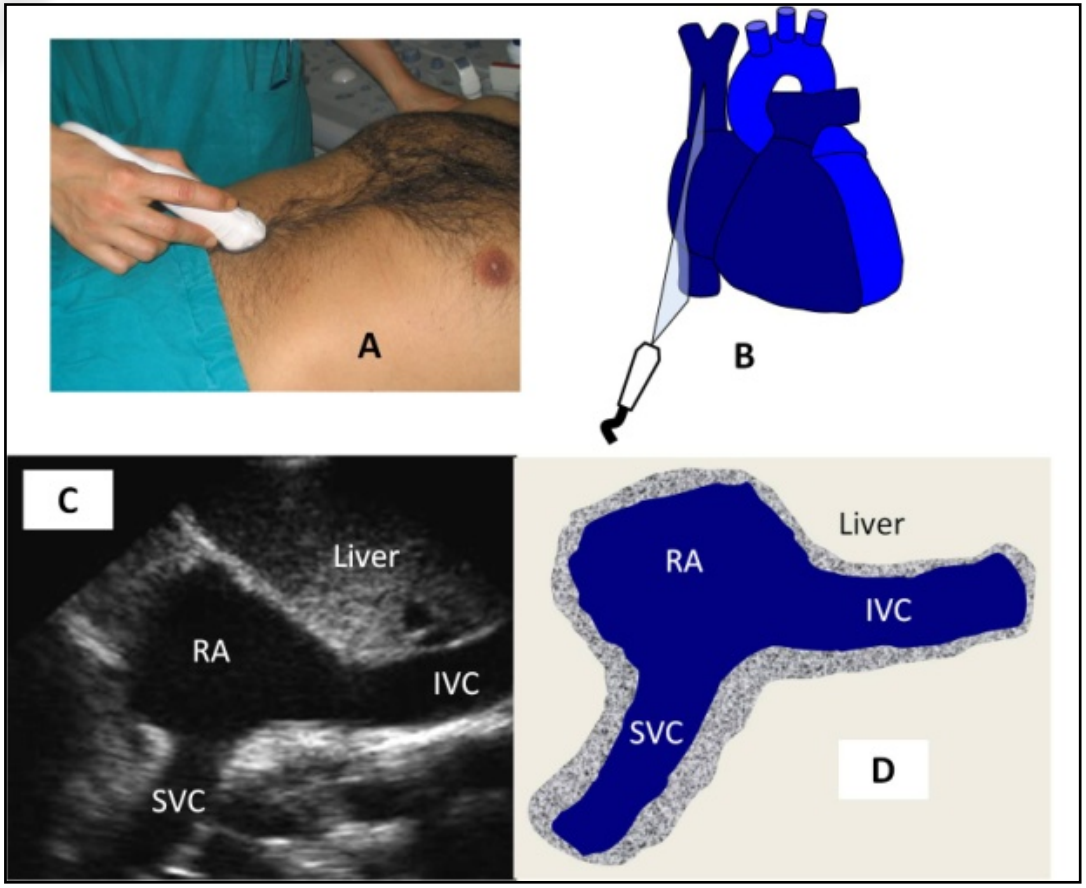
- The most accurate
- Invasive
- Specialty-based
- Only for patients under general anesthesia

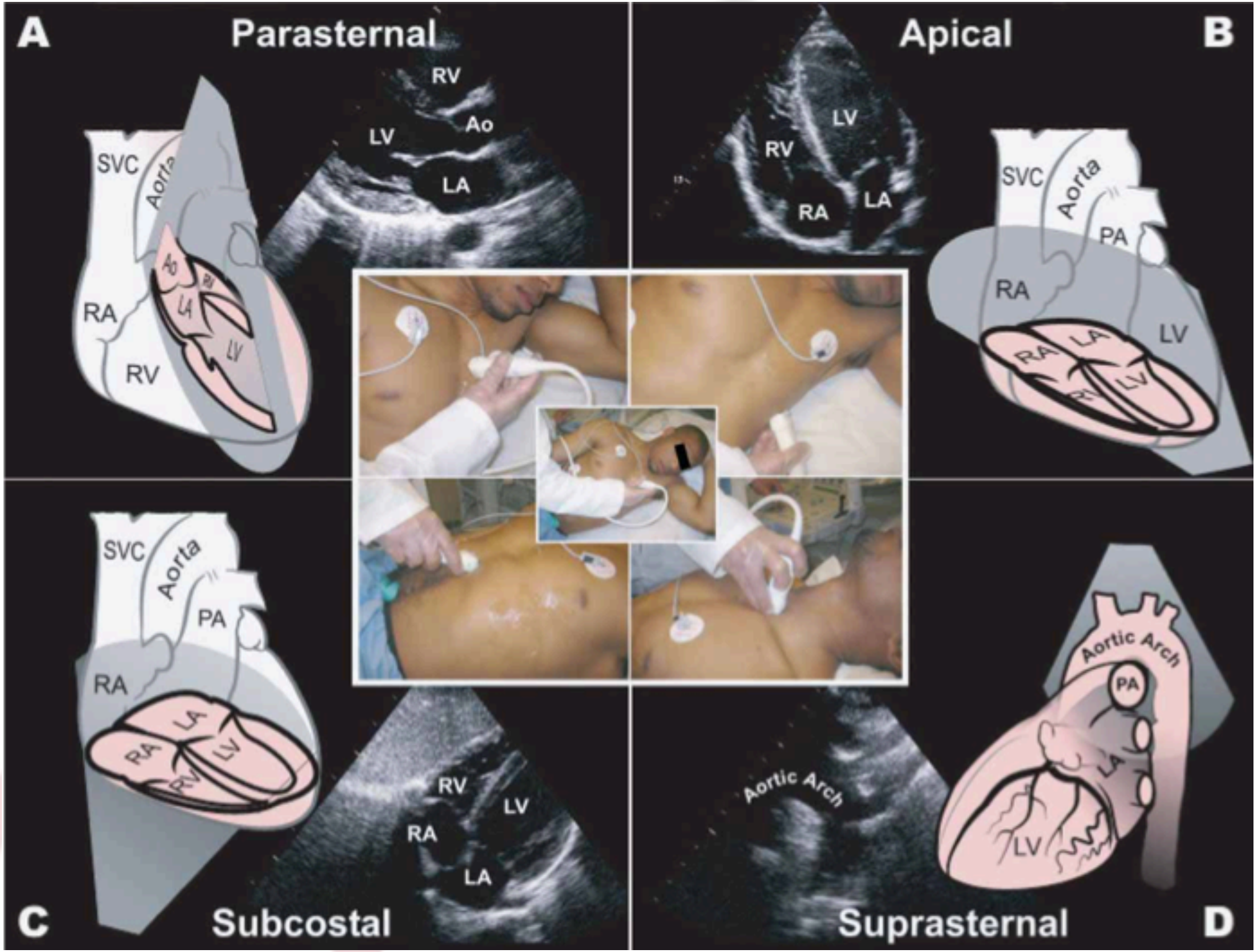


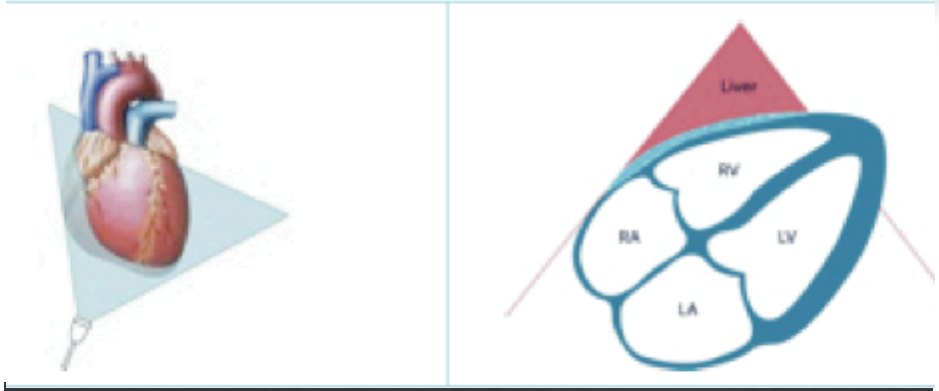
Intra-procedural tip location: Trans-Thoracic Ecocardiography

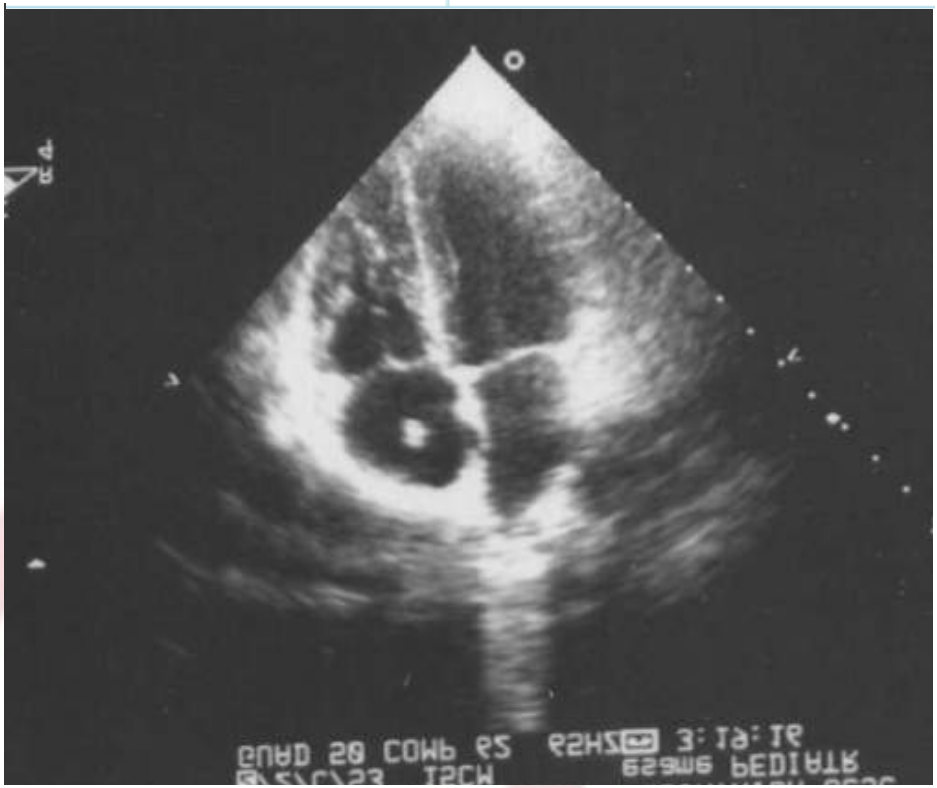


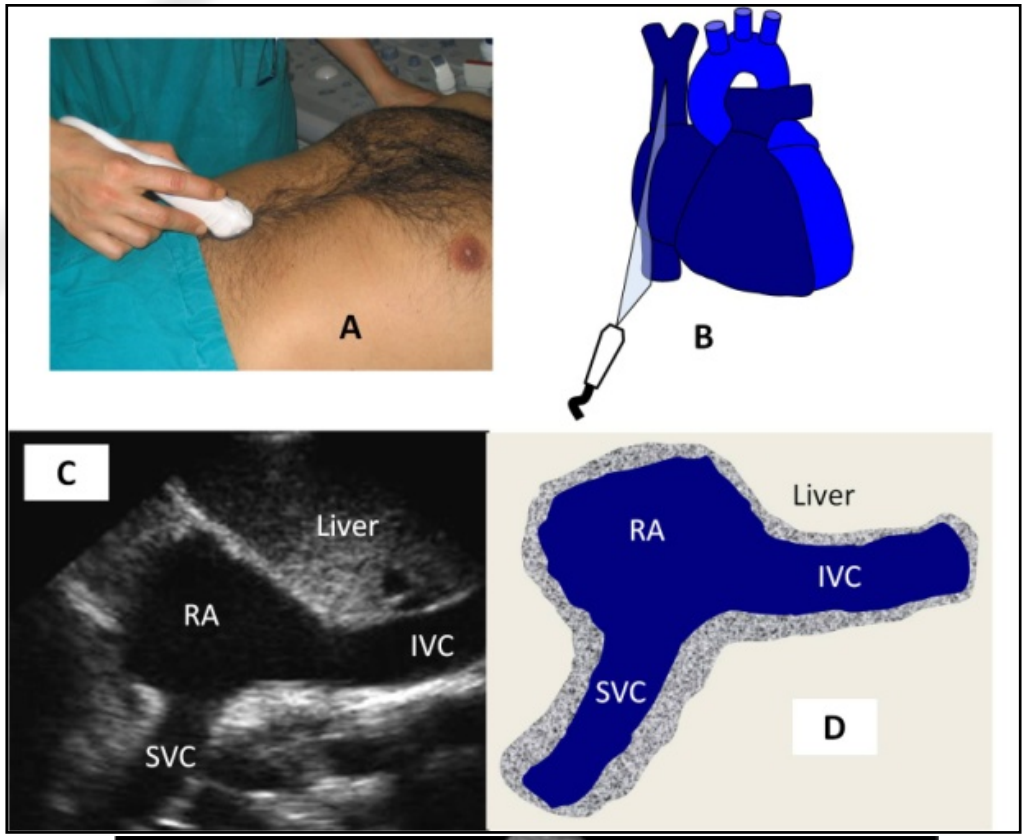


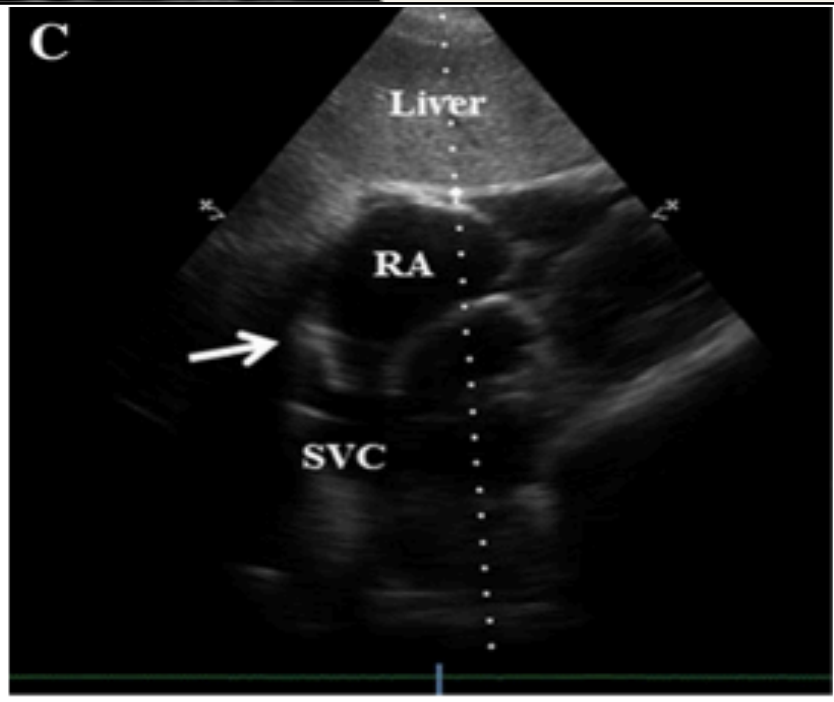


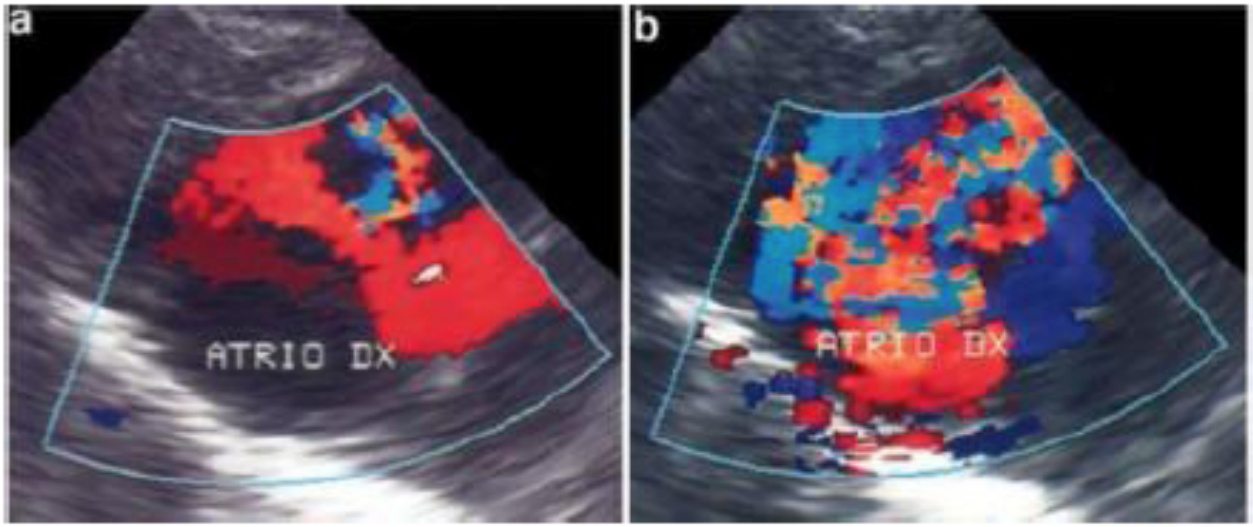

A
Parasternal
RV
Ao
LV
LA
SVC
Aorta
RA
RV
LV
B
Apical
LV
RV
RA
LA
SVC
Aorta
PA
RA
LV
C
Subcostal
SVC
Aorta
PA
RA
LA
RV
LV
RV
LV
RA
LA
D
Suprasternal
Aortic Arch
PA
LA
LV
Aortic Arch

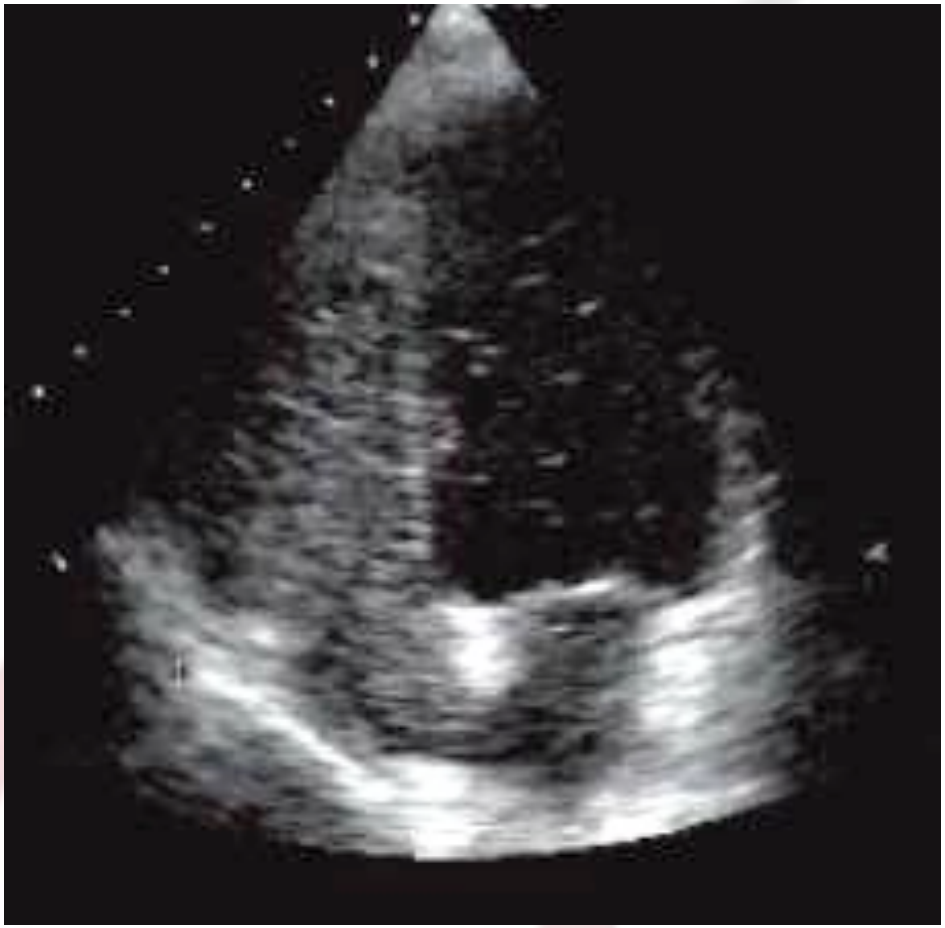

Liver
RV
RA
LV
LA




A
B
C
Liver
RA
IVC
SVC
Liver
RA
IVC
SVC
D


C
Liver
RA
SVC


a
ATRIO DX
b
ATRIO DX



Ultrasonic Examination

AMERICAN JOURNAL OF RESPIRATORY AND CRITICAL CARE MEDICINE VOL 164 2001

An Alternative to Chest Radiography after Central Venous Catheter Insertion?

ERIC MAURY,
Service de Réanim

Negative assessment:
IJV & SCV (supraclavicular view), RA (subcostal view)

Jerome Bedel

Negative assessment:
RA (subcostal view) + predictive length

Guidewire localization by transthoracic echocardiography during central venous catheter insertion: a periprocedural method to evaluate catheter placement

Intensive Care Med (2013) 39:1932–1937

Ultrasound localization of central vein catheter and detection of postprocedural pneumothorax: An alternative to chest radiography*

Crit Care Med 2010 Vol. 38, No. 2

Antonella Vezzani,
Mario Mergoni, M

"Positive" assessment:
Saline + air bubbles in linear flow or color signals appearing within 1-2 seconds (subcostal view)

Brief Report

American Journal of Emergency Medicine 32 (2014) 78–81

Contrast enhanced ultrasound vs chest X-ray to determine correct central venous catheter position

Francesca Cortellaro, MD [a,*], Luca Mellace, MD [a], Stefano Paglia, MD [a], Giorgio Costantino, MD [c],

Intra-procedural tip location: Trans-Thoracic Ecocardiography

- Direct visualization of the tip difficult in adult patients
- Direct visualization of the tip usually possible only if located in the right atrium
- Contrast / Doppler based indirect visualization under evaluation studies
- Better visualization in pediatrics (neonates)

Intra-procedural tip location: Trans-Thoracic Ecocardiography

The future (TTE)

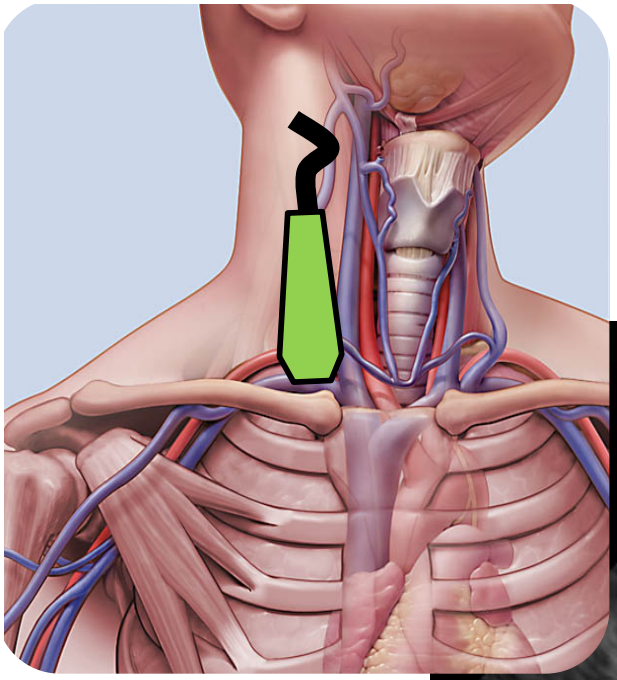
Standardization of TTE for tip location:

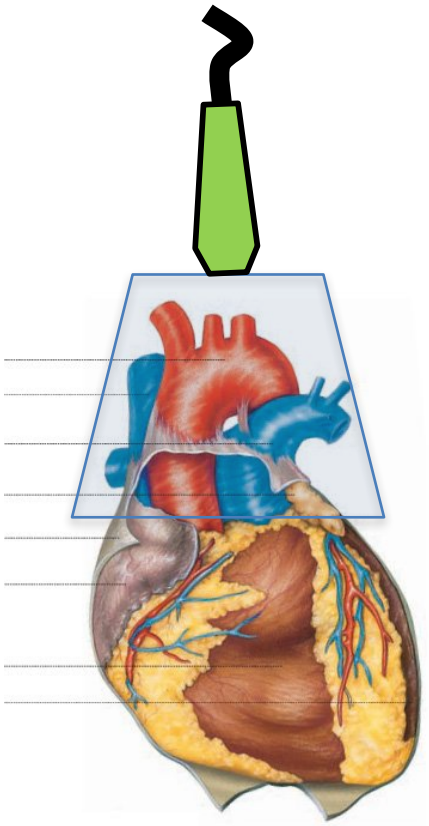
1) *Tip to be placed in lower 1/3 of SVC:*

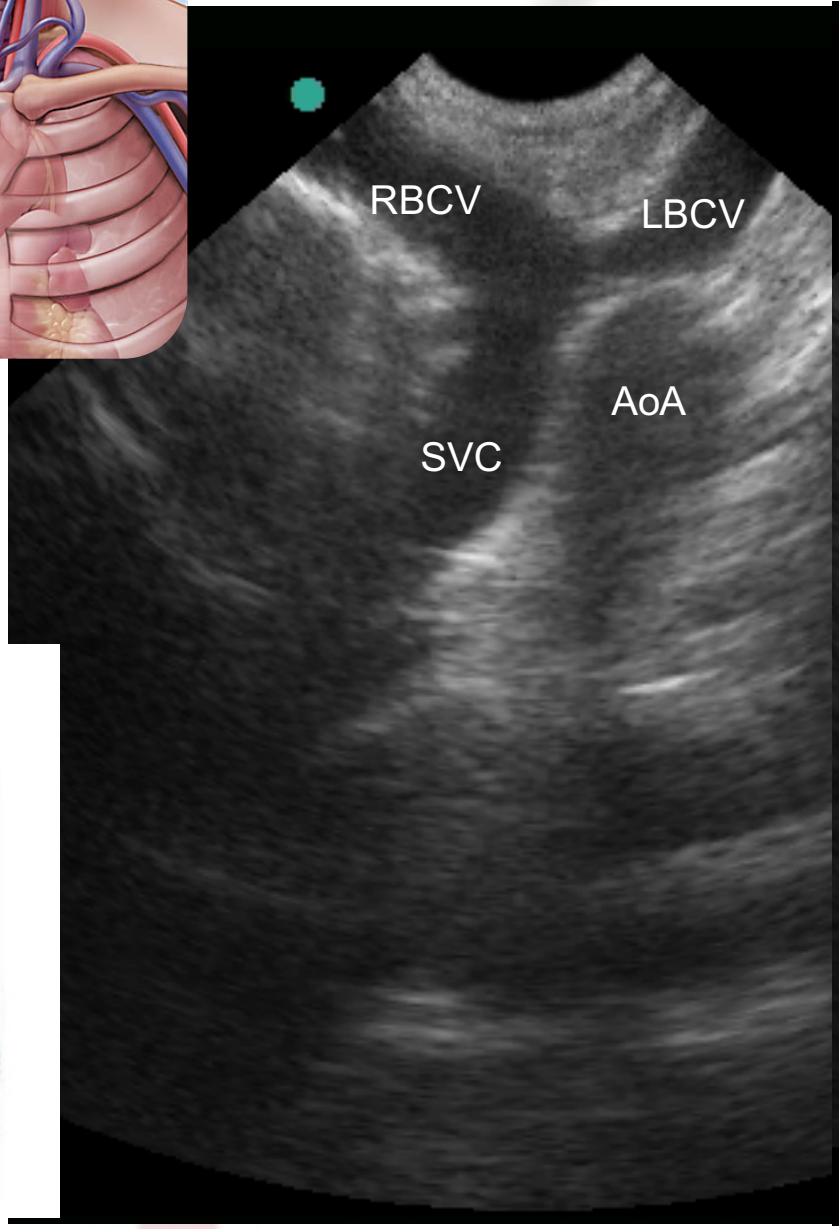
- Subcostal view: direct tip visualization in SVC
- Apical view: RA visualization + echo-contrast infusion (contrast appearing in RA within 1-2 sec) or saline infusion (color doppler changes in RA within 1-2 sec)
- Apical view: direct tip visualization in RA + pulling back the catheter until tip disappears

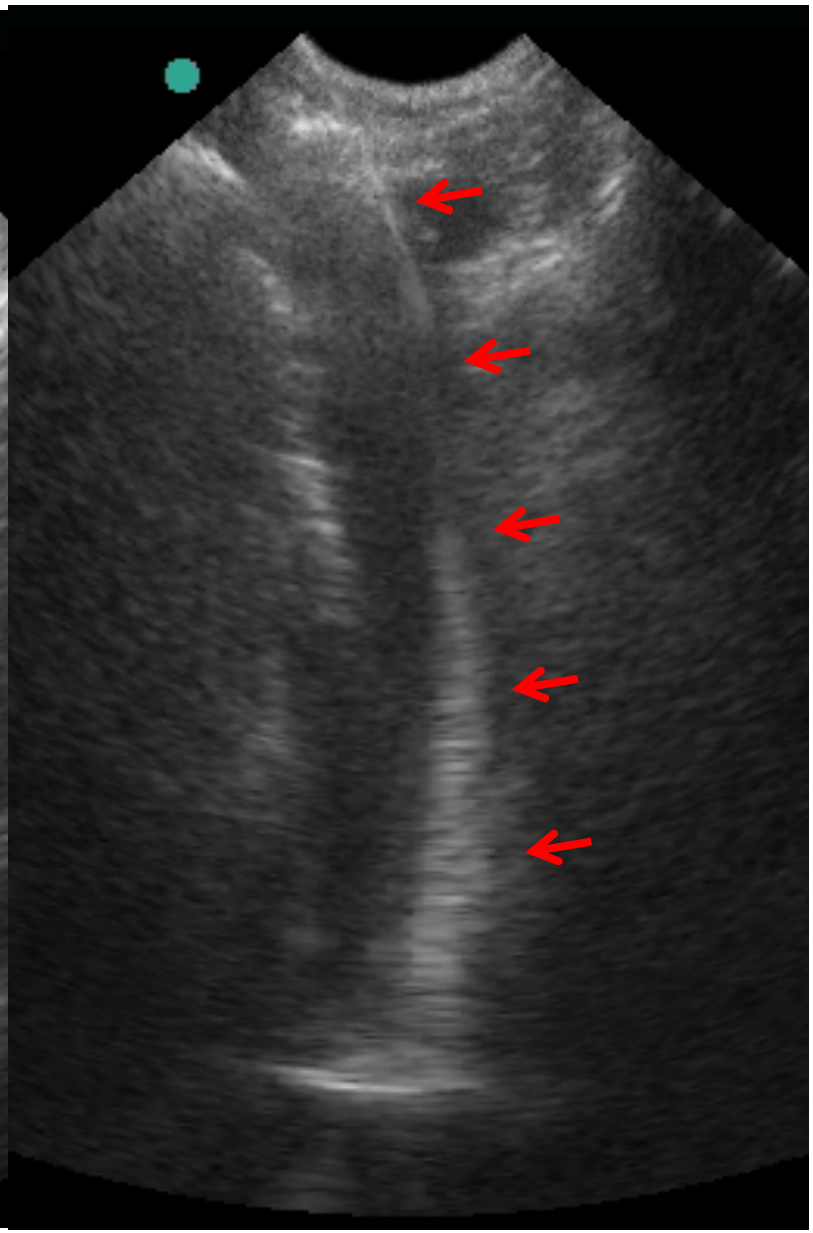
2) *Tip to be placed in RA*:

- Apical view: direct tip visualization in RA






RBCV
LBCV
AoA
SVC



Intra-procedural tip location: Trans-Thoracic Ecocardiography Via Microconvex probe

"IMPROVING THE "GLOBAL USE" OF ULTRASOUND FOR CENTRAL VENOUS ACCESS: A NEW SUPRACLAVICULAR SCAN BY MICROCONVEX PROBE"

- PART 1: MCP tested on 10 patients in order to define its accuracy in
  (1) identifying nerve-vascular bundles
  (2) visualizing the brachiocephalic-caval venous axis via the right supra-clavicular approach
  (3) detecting the pleural 'sliding sign' (rule out of pneumothorax).
  In all patients, all three goals were achieved.
- PART 2: 6 CVC placements, to test the possibility of adopting the MCP for
  a) systematic scan of central veins (RaCeVA protocol)
  b) puncture and cannulation of central veins (3 internal jugular veins and 3 axillary veins)
  c) visualization of catheter/guidewire within the great vessels (via the right supraclavicular scan) so to locate the tip in the lower portion of the superior vena cava (SVC)
  d) detection of pleural complications.

Intra-procedural tip location: Trans-Thoracic Ecocardiography Via Microconvex probe

"IMPROVING THE "GLOBAL USE" OF ULTRASOUND FOR CENTRAL VENOUS ACCESS: A NEW SUPRACLAVICULAR SCAN BY MICROCONVEX PROBE"

- The MCP was effective for all of these purposes, with some concerns only with tip location:
  - –metal guidewire visible within the SVC in all 6 patients
  - –Tip recognizable below the crossing between SVC and right pulmonary artery in only 2 cases
  - –Catheter never recognizable within the great vessels, maybe because of its low echogenicity as compared to the metal guidewire.
- Our pilot study suggests that the MCP may be used in all steps of CVC insertion. The supra-clavicular scan is a promising view for visualization of the guidewire within the great vessels deep into the SVC, though its effectiveness for tip location is still uncertain.

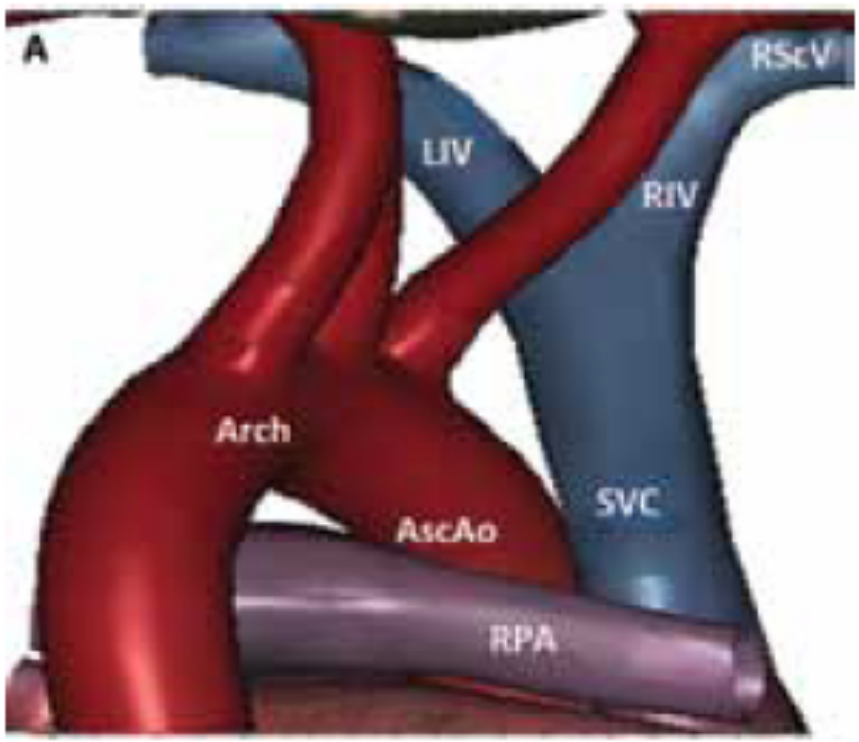
JVA
ISSN 1129-7298

J Vasc Access 2016; 17 (5): 435-439
DOI: 10.5301/jva.5000518

ORIGINAL RESEARCH ARTICLE

Ultrasound-guided supraclavicular central venous catheter tip positioning via the right subclavian vein using a microconvex probe

Se-Chan Kim[1], Ingo Gräff[1], Alexandra Sommer[2], Andreas Hoeft[1], Stefan Weber[1]



Intra-procedural tip location: Trans-Thoracic Ecocardiography

Intensive Care Med (2012) 38:1105–1117
DOI 10.1007/s00134-012-2597-x

Massimo Lamperti
Andrew R. Bodenham
Mauro Pittiruti
Michael Blaivas
John G. Augoustides

International evidence-based recommendations on ultrasound-guided vascular access

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

Intra-procedural tip location: Trans-Thoracic Ecocardiography

3. Use caution with ultrasound for CVAD tip location, as its use in replacing chest radiographs is controversial in all ages due to small sample sizes in available studies and lack of standardized techniques. Consider use in neonates and in emergency departments when immediate knowledge of the CVAD tip location is beneficial.

Intra-procedural tip location in the IC-ECG unsuitable patients: how ?

- Introducing alternative tip location methods
- Adding further tip location and/or navigation technologies to IC-ECG
- Improving applicability of IC-ECG (modified IC-ECG)
- Integrating all the above mentioned strategies (an algorithm)

Intra-procedural tip location in the IC-ECG unsuitable patients: how ?

- Adding further tip location and/or navigation technologies to IC-ECG

Improving feasibility: “integrated devices” (ECG+navigation)

ECG + doppler

Green Arrow – Keep going
The catheter is moving with the flow of the blood towards the heart.

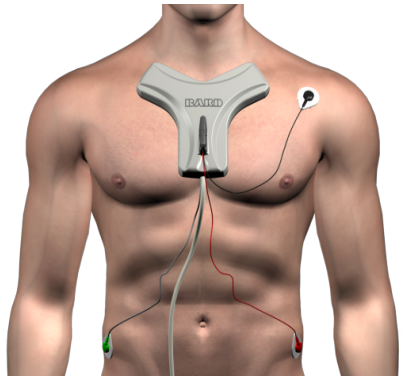
Orange Circle – Do not enter
The catheter is moving against the flow of the blood. It needs to be pulled back and redirected.

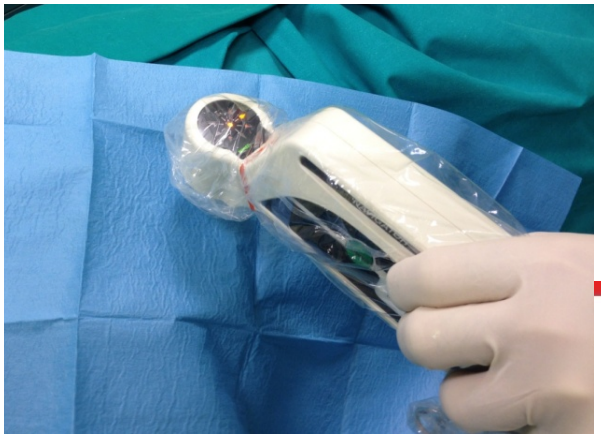
Yellow Triangle – Redirect catheter
The catheter is possibly against the blood vessel wall. It needs to be pulled back and repositioned.

Blue Bull’s Eye – Correct Placement
The catheter tip has arrived within the lower ⅓ SVC and the CAJ.

ECG
+ presso-acoustic waves

ECG
+ electromagnetic tracking



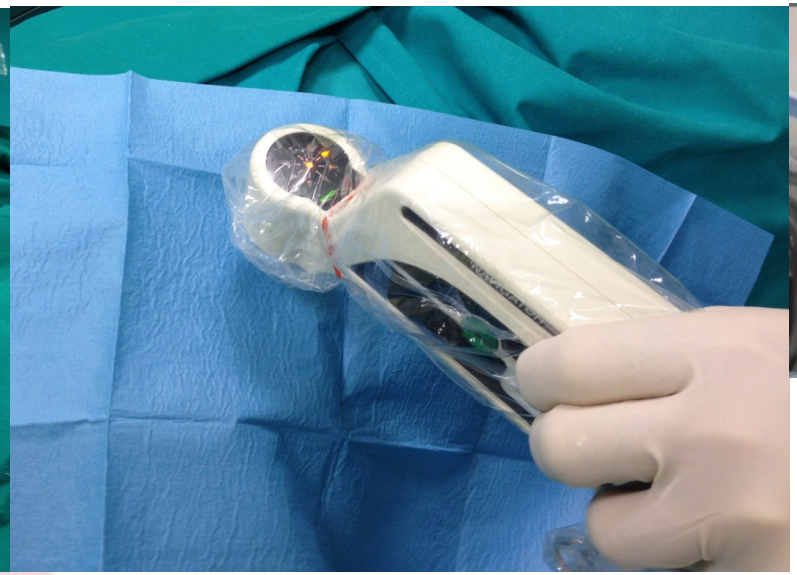


Adding a navigation system may help directing the tip towards the SVC thus obtaining the expected variations in amplitude of P wave or T-Q segment

Improving feasibility: IC-ECG + navigation study

"TIP NAVIGATION + TIP LOCATION: AN ALGORITHM FOR MAXIMIZING SAFETY AND COST-EFFECTIVENESS OF CENTRAL VADs"

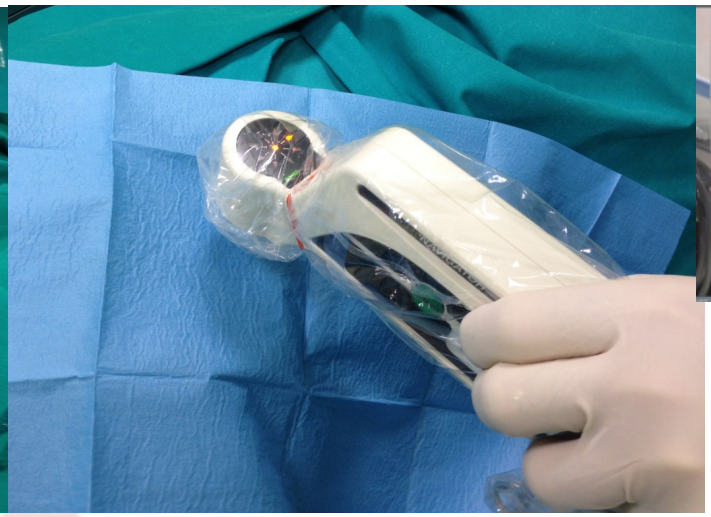
- 30 patients consecutively studied during PICC placement
- Navigator (Corpak) as tip navigation system
- Intracavitary ECG method for tip location.



WoCoVA
World Congress Vascular Access

Improving feasibility: IC-ECG + navigation study

- The tip navigation device was successfully used in all patients, making the procedure easier and faster.
- In all patients, the correct tip location as evaluated by the intracavitary ECG method corresponded to the electromagnetic detection of the tip below the third intercostal space, with the tip properly directed downward.



WoCoVA
World Congress Vascular Access

Improving feasibility: IC-ECG navigation!!!

Improving feasibility: IC-ECG navigation!!!

Improving feasibility: IC-ECG navigation!!!

Improving feasibility:
IC-ECG navigation!!!

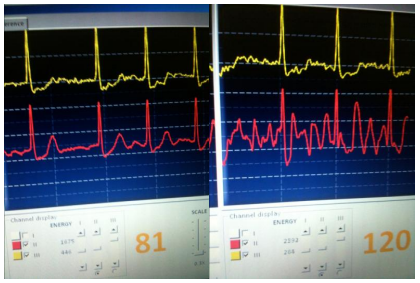
Improving feasibility:
IC-ECG navigation!!!

Intra-procedural tip location in the IC-ECG unsuitable patients: how ?

- Introducing alternative tip location methods
- Adding further tip location and/or navigation technologies to IC-ECG
- Improving applicability of IC-ECG (modified IC-ECG)
- Integrating all the above mentioned strategies (an algorithm)

Intra-procedural tip location in the IC-ECG unsuitable patients: how ?

- Improving applicability of IC-ECG (modified IC-ECG)



Improving applicability of IC-ECG (atrial fibrillation)

The mean increase of the baseline electrical activity on the intracavitary ECG recorded in patients with atrial fibrillation may be used for detecting the transition of the catheter electrode from the superior vena cava to the right atrium

(Engelhardt 1984; Pittiruti et al. 2011 and 2016)

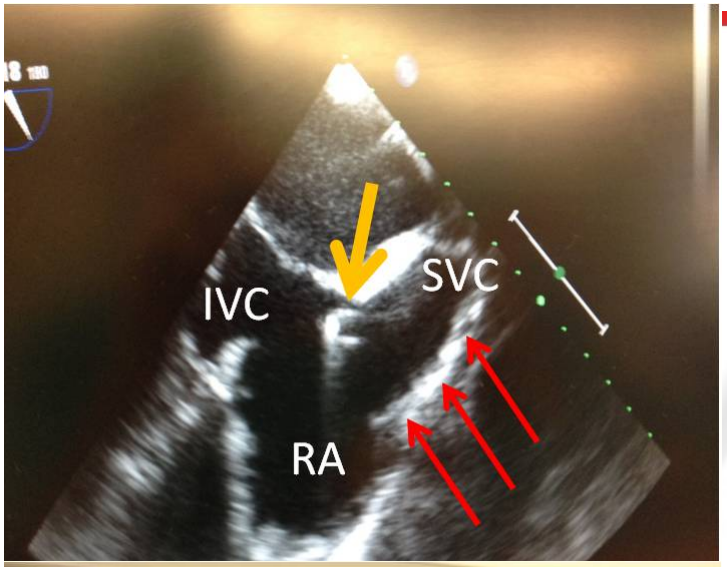
Improving applicability
FA – Study 1

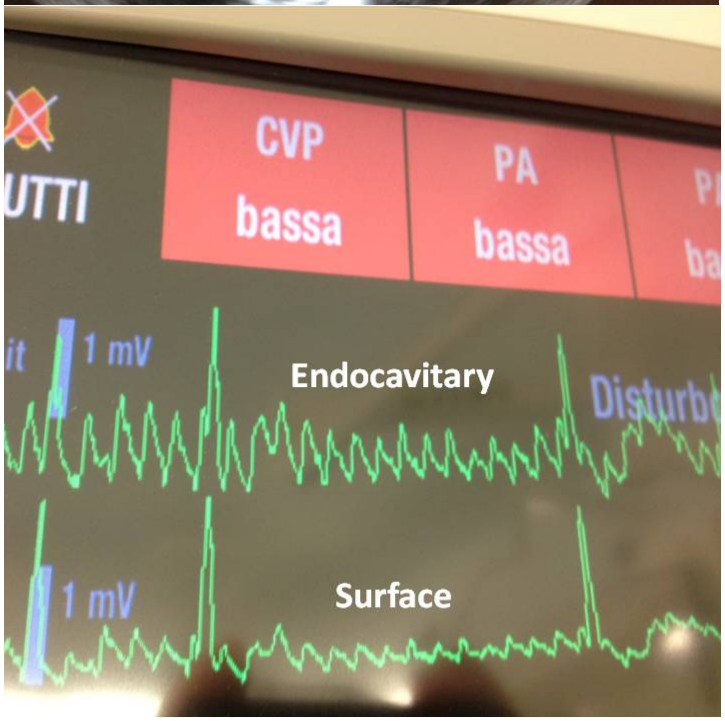
"EKG-controlled placement of central venous catheters in patients with atrial fibrillation"
(Pittiruti, La Greca, Scoppettuolo et al. - INS 2011)

- Cavo-atrial junction was detected by two criteria:
  - (a) abrupt appearance of high-voltage waves when entering the right atrium and their brisk disappearance when pulling the catheter back into the vena cava superior;
  - (b) sudden increase (4-fold, 10fold) of the amount of energy recorded by the intracavitary electrode
- Post-op. chest x-ray in all patients
- Cavo-atrial junction correctly identified in 25 pts. out of 27
- Conclusion: the EKG method for verifying the position of the tip of central venous access devices can be applied in most patients with atrial fibrillation, with high accuracy (no false positives; few false negatives).

WoCoVA
World Congress Vascular Access

Improving applicability
FA – Study 2

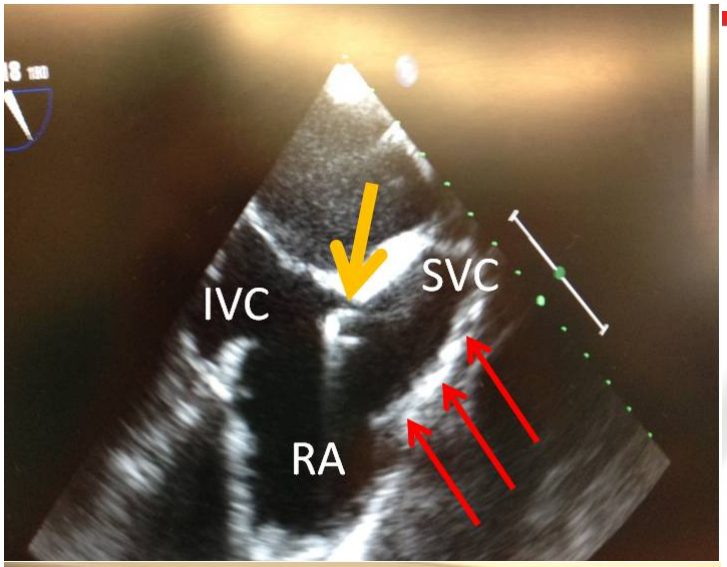


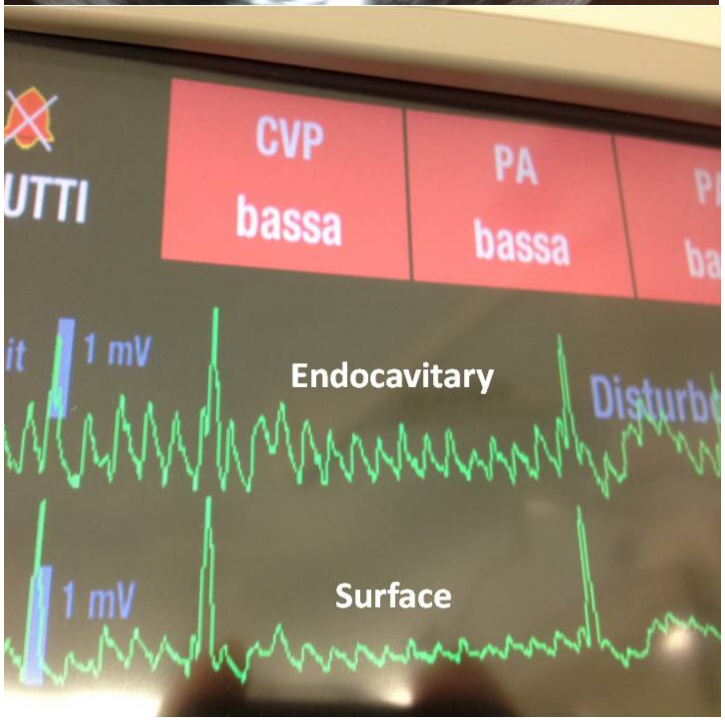


- Patients affected by atrial fibrillation and candidate to cardiac surgery (aorto-coronaric bypass, valvular replacement) under emodynamic monitoring via trans-esophageal echocardiography + CVAD placement in the operating room have been consecutively enrolled.
- In each patient, the TEE probe was inserted after completion of the general anesthesia procedure and adjusted to obtain the atrio-bicaval view according to the Medical Society of Echocardiography guidelines.

UNIVERSITÀ CATTOLICA del Sacro Cuore

Improving applicability
FA – Study 2

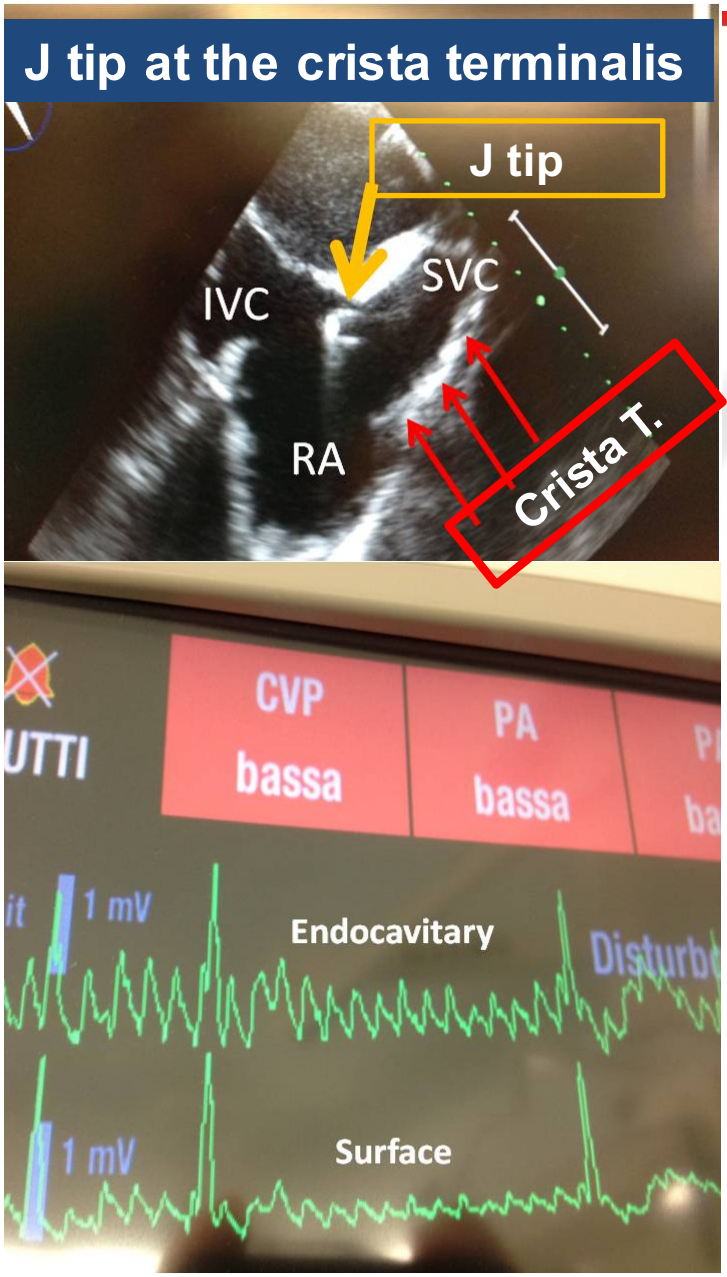




- The CVAD was inserted under ultrasound and IC-ECG guidance according to our Institution standard policy.
- The CVAD tip was placed at the CAJ as defined with regard to the crista terminalis, the anatomical and US landmark of the CAJ and then threaded 2 cm below and pulled 2 cm above it always under TEE guidance.
- The IC-ECG traces corresponding to the three US-based tip positions were saved for subsequent analysis and the catheter was left in situ at the point defined by TEE.

UNIVERSITÀ CATTOLICA del Sacro Cuore

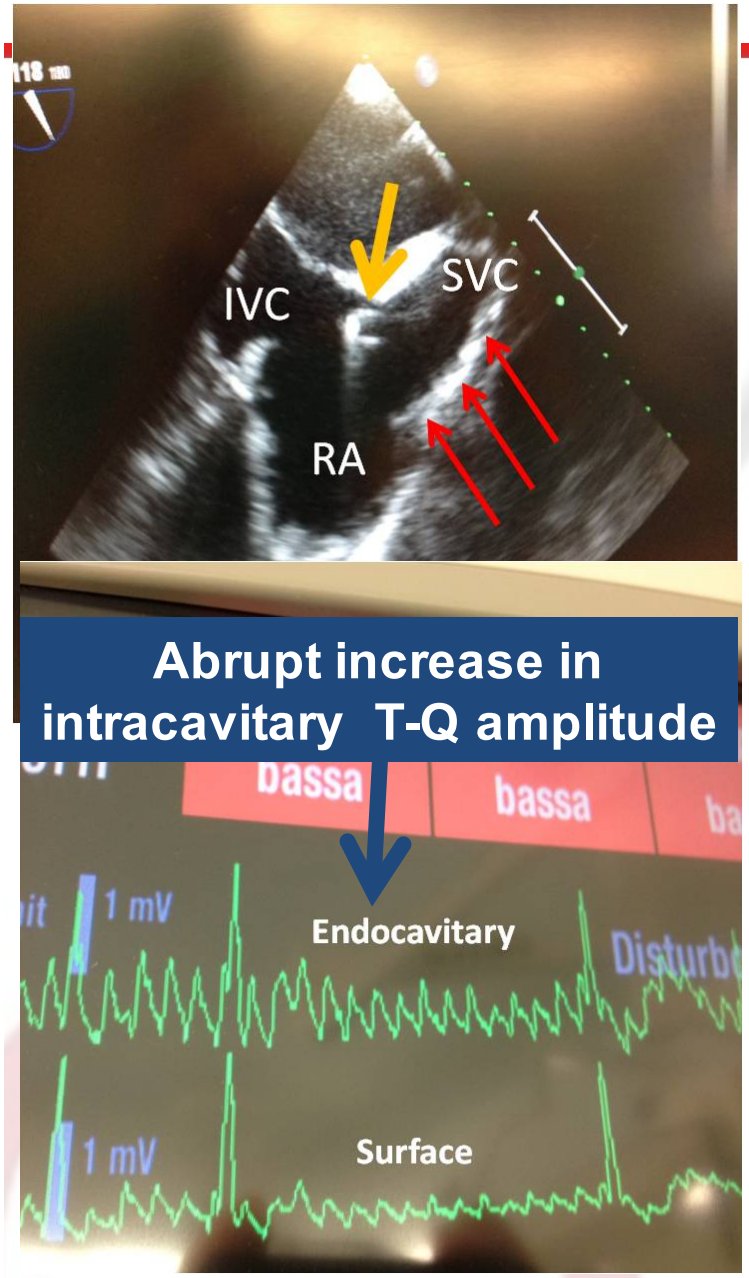
Improving applicability
FA – Study 2



- To date, 4 consecutive patients have been enrolled and included in the analysis.
- CVAD insertion successful and uneventful in all patients.
- All CVADs inserted via the right IJV.
- Guidewire J-tip exiting the catheter and the crista terminalis clearly located by the TEE operator in all patients.

UNIVERSITÀ CATTOLICA del Sacro Cuore

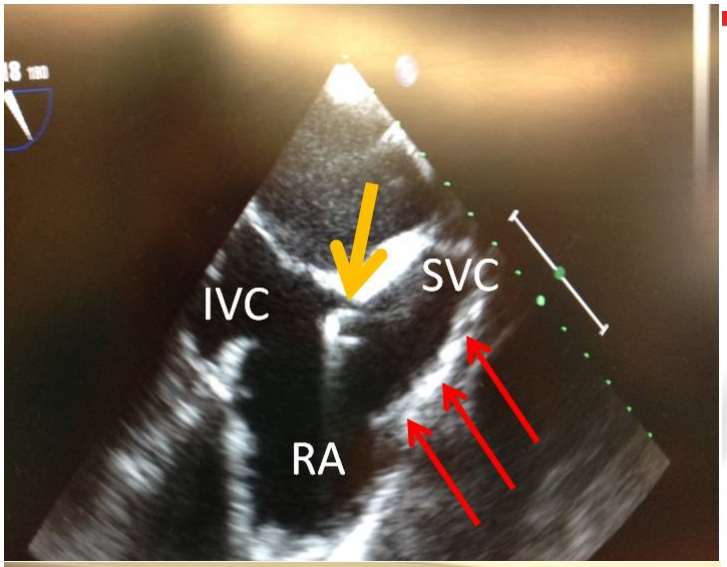
Improving applicability
FA – Study 2

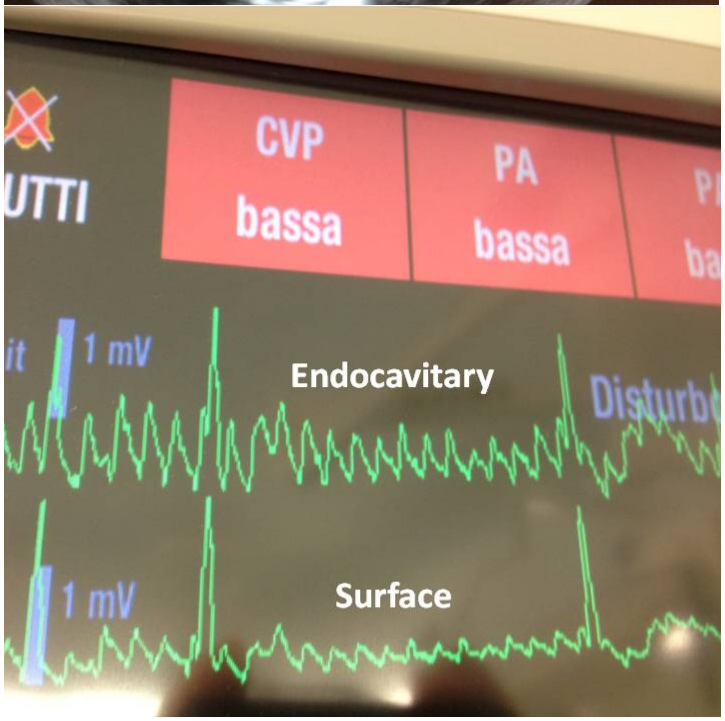


- Under TEE, an abrupt increase in the mean intracavitary amplitude of the asynchronous atrial electrical activity (i.e. the T-Q segment on the ECG trace) as compared to the surface trace is recorded with the J-tip placed at the crista terminalis.
- A clear reduction in amplitude is evident in the two alternative positions (SVC and deep RA) in all patients.

UNIVERSITÀ CATTOLICA del Sacro Cuore

Improving applicability
FA – Study 2





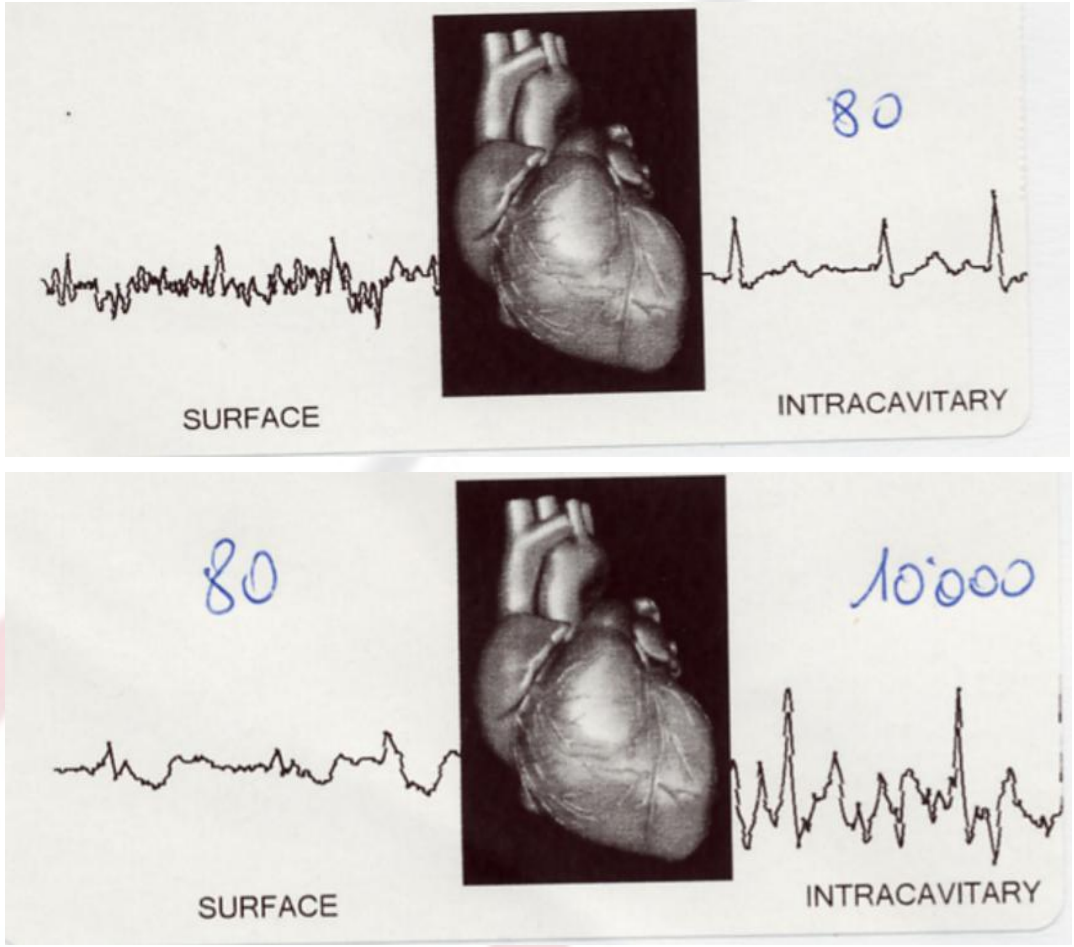
- While patients are being enrolled, further IC-ECG traces analysis is ongoing to define quantitative parameters allowing a more refined correlation between IC-ECG and tip position in FA patients (i.e.: energy et al.)

WoCoVA
World Congress Vascular Access

Improving applicability of IC-ECG (atrial fibrillation)

Using specialized “digital” ECG monitors

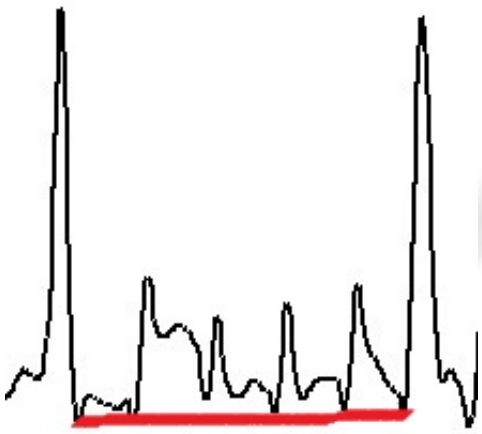
The area under the T-Q segment = atrial energy



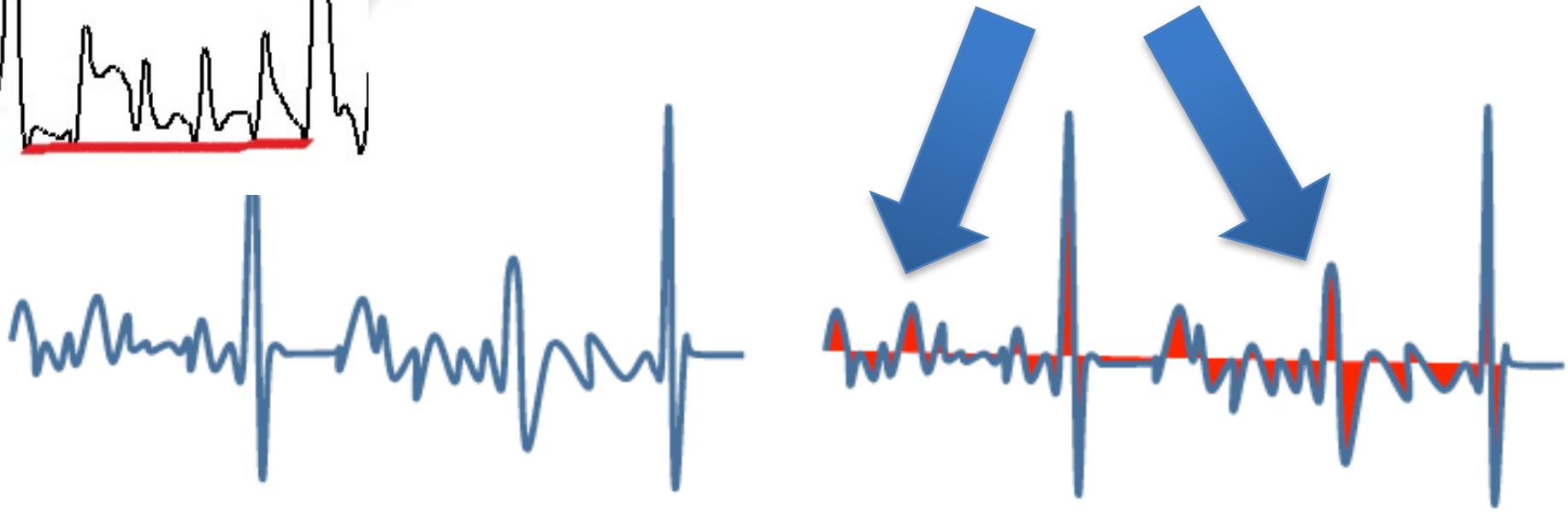
Improving applicability of IC-ECG (atrial fibrillation)

Using specialized "digital" ECG monitors

The area under the T-Q segment (atrial "energy") might be related to the cavo-atrial junction tip location



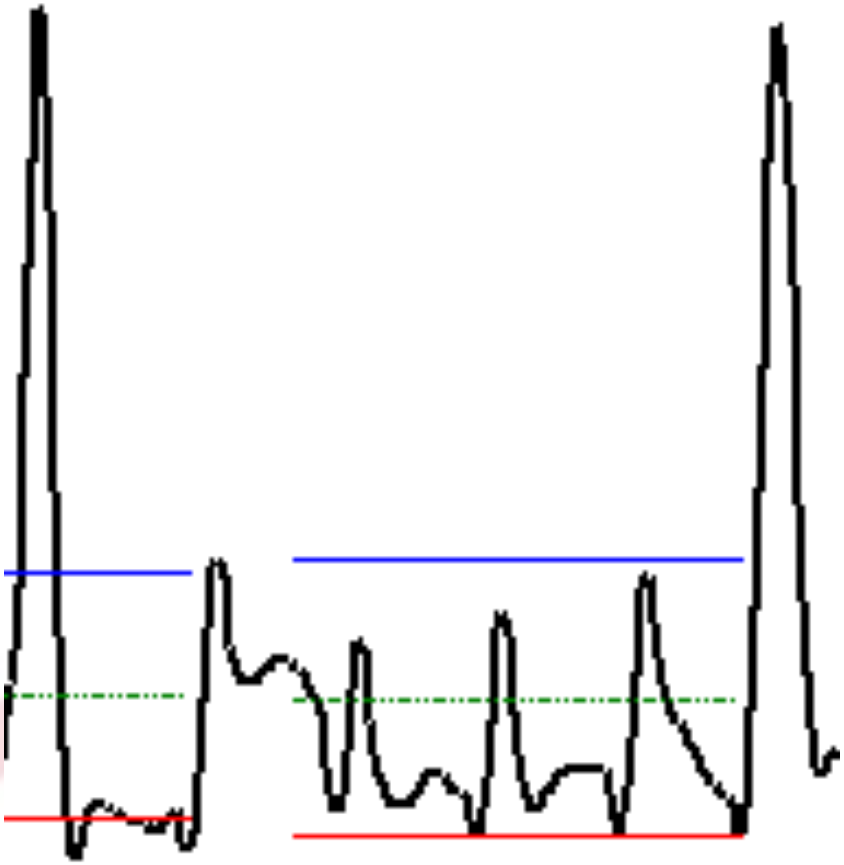
But it is different during examination in the same tip position !!! (different duration of the T-Q segment)

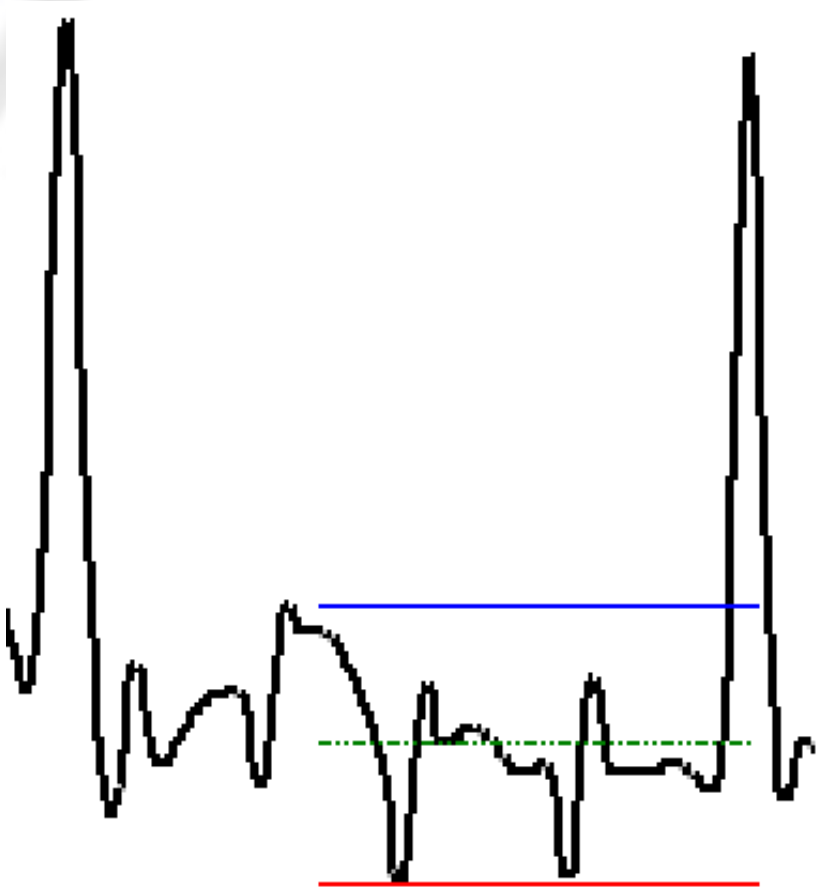


Improving applicability
FA – Study 3

Using specialized “digital” ECG monitors

The median peack-to-peack maximal voltage might be related to the cavo-atrial junction tip location (more costant in different measurements at the same tip position)





So, can we improve IC-ECG results ?

… yes, we can !

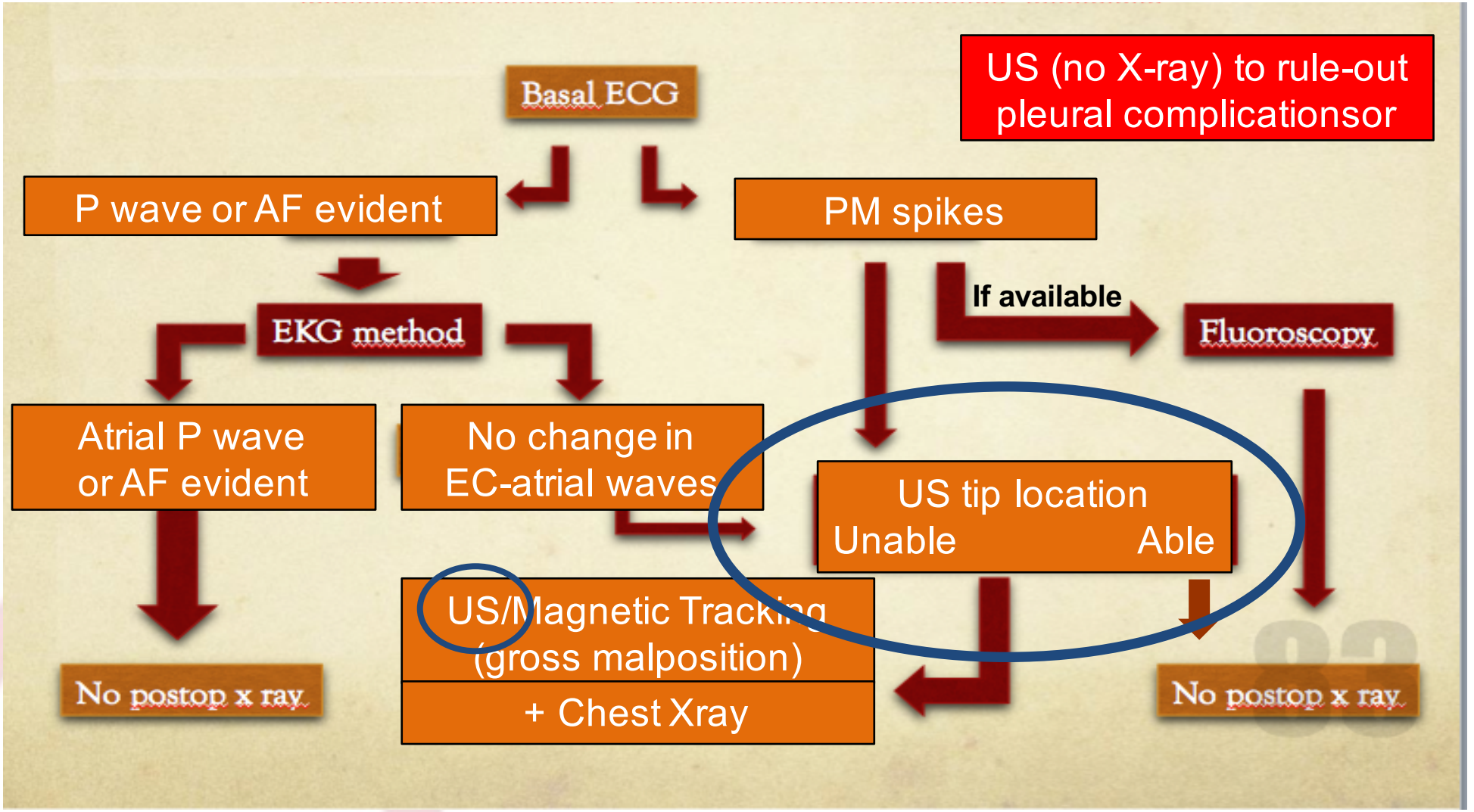
So, can we completely avoid X-Ray based tip control in all patients ?

... maybe !

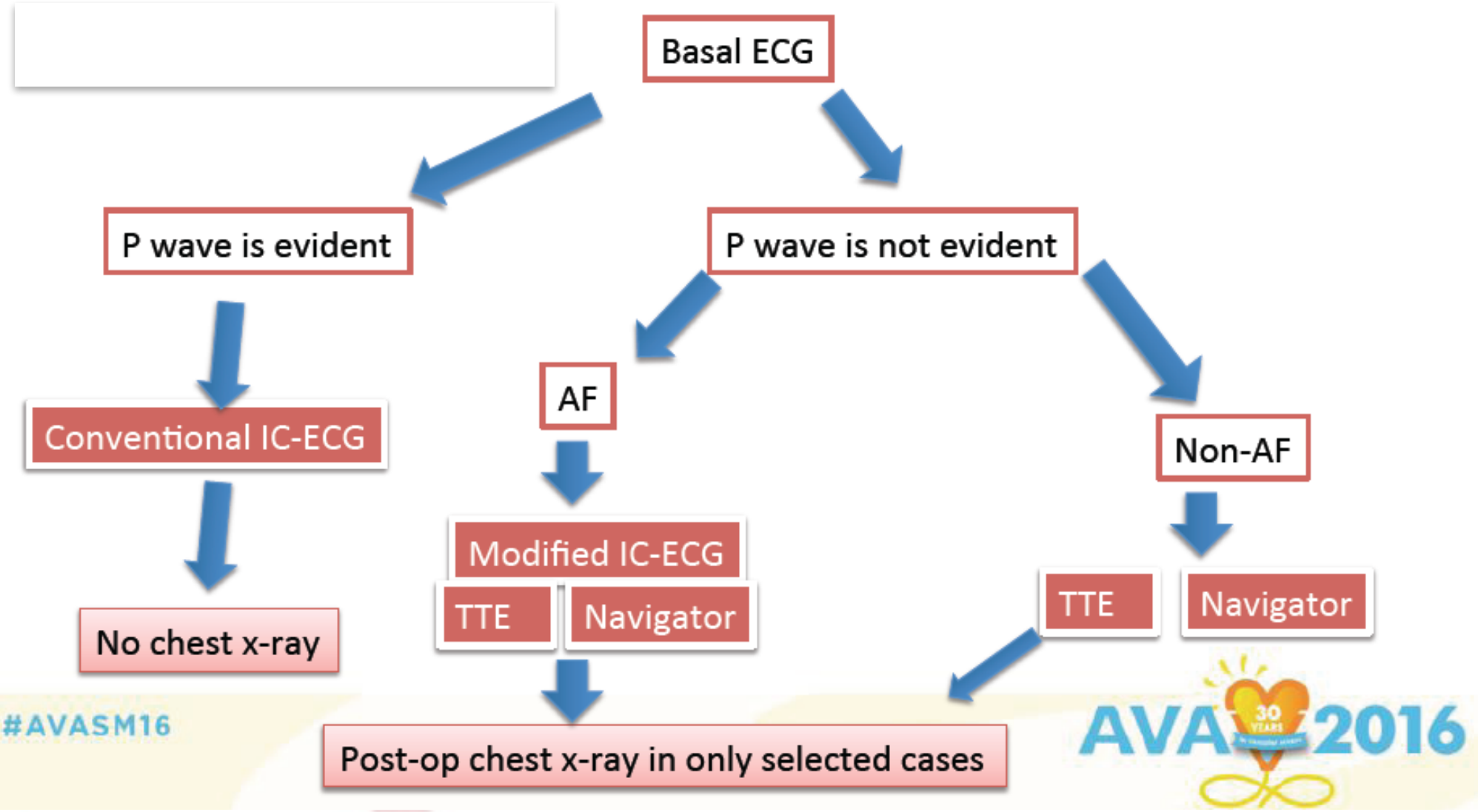
Improving IC-ECG results

UNIVERSITÀ CATTOLICA del Sacro Cuore

Our proposal of an "advanced" algorythm



Improving tip location
Our proposal of an “advanced” algorythm



Thanks !!!

GAVeCeLT
Gli Accessi Venosi Centrali a Lungo Termine

UNIVERSITÀ CATTOLICA del Sacro Cuore

Policlinico Agostino Gemelli
Università Cattolica del Sacro Cuore
Gemelli