Trans-Esophageal Echo in Resuscitation

Michael Blaivas, MD, FACEP, FAIUM
Clinical Professor of Medicine
University of South Carolina School of Medicine
AIUM, Third Vice President
President, Society for Ultrasound Medical Education
Past President, WINFOCUS
Editor, Critical Ultrasound Journal
Sub-specialty Editor, Journal of Ultrasound in Medicine
Emergency Medicine
Atlanta, Georgia
mike@blaivas.org

Disclosures

- No relevant disclosures to lecture

Objectives

- Discuss focused application of TEE in emergency and critical care situations
- Discuss TEE for peri-resuscitation management
- Discuss possible complications and limitations to TEE use
- Discuss possible future direction of TEE in emergency and critical care ultrasound

Echo Use in Resuscitation

- Resuscitation management while flying blind is frustrating
- In many cases providers are unaware of what is actually happening to the patient
- Is there cardiac activity?
- Are there cardiac contractions?

Echo Use in Resuscitation

- There is considerable use for echo in resuscitation
- Most experts agree on this and even novices quickly realize the utility
- Outperforms the physical examination and in most cases the electrocardiographic evaluation as well

Echo Use in Resuscitation

- Reversible causes include:
  - pericardial effusion
  - hypovolemia
  - pneumothorax
  - pulmonary embolism
  - depressed myocardial function
  - Others…

Echo Use in Resuscitation

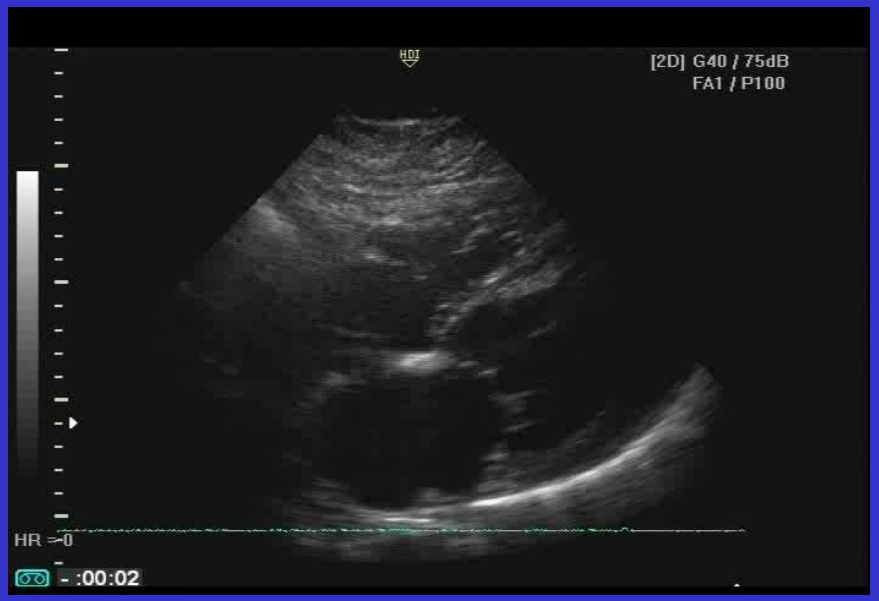
- Both agencies advise focusing on patients with PEA
- Look for reversible causes
- Maximize quality chest compressions and minimize breaks

Echo in Resuscitation

- Allows detection of myocardial standstill
- Considerable evidence suggestion such patients will not survive if they did not respond to initial pre-hospital efforts
- If other than standstill, helps manage resuscitation effort

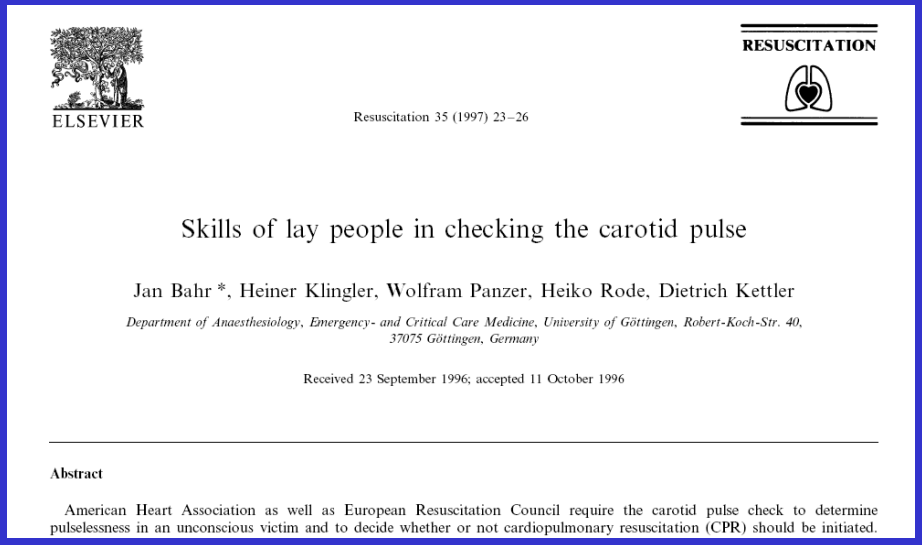
TTE in Resuscitation

- Not infrequent to find pseudo EMD with mechanical contractions in place
- What does that mean in a patient who has no palpable pulses?
- How accurate is pulse assessment?



Are They Dead or Alive?

- 449 lay persons checking pulses: 47.4% detected in 5 seconds, 73.7% in 10 seconds
- Medical professionals: Med students and EMS took 18.3 sec to find pulse in unconscious patient



ELSEVIER

Resuscitation 35 (1997) 23–26

RESUSCITATION

Skills of lay people in checking the carotid pulse

Jan Bahr *, Heiner Klingler, Wolfram Panzer, Heiko Rode, Dietrich Kettler

Department of Anaesthesiology, Emergency- and Critical Care Medicine, University of Göttingen, Robert-Koch-Str. 40, 37075 Göttingen, Germany

Received 23 September 1996; accepted 11 October 1996

Abstract

American Heart Association as well as European Resuscitation Council require the carotid pulse check to determine pulselessness in an unconscious victim and to decide whether or not cardiopulmonary resuscitation (CPR) should be initiated.

Pulse Palpation in Resuscitation

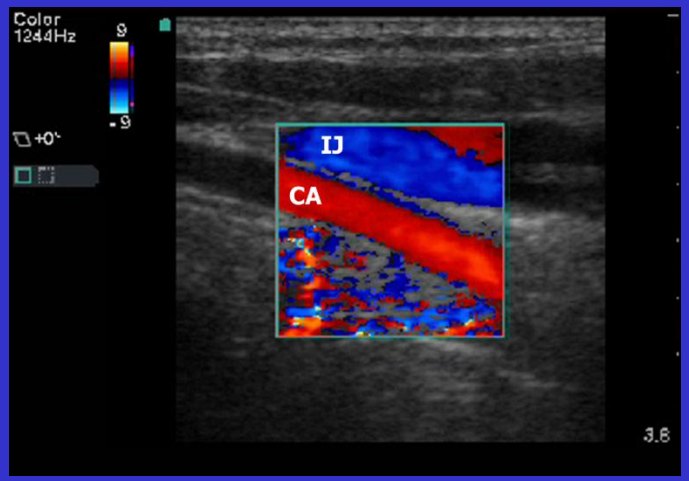
- Used to determine need for chest compressions
- Earlier data questions our ability to be accurate
- How often does echo agree with pulse palpation in cardiac arrest resuscitation?

Pulse Palpation in Resuscitation

- Studied patients in arrest with POC echo
- 47% of patients felt to have adequate EF had no pulses detected
- 11% of the time when nurses/physicians detected pulse there was no cardiac activity
- Blaivas M. Discordance Between Pulse Detection and Emergency Echocardiography Finding in Adult Cardiopulmonary Resuscitation. Ann Emerg Med. 2008; 52:S128.

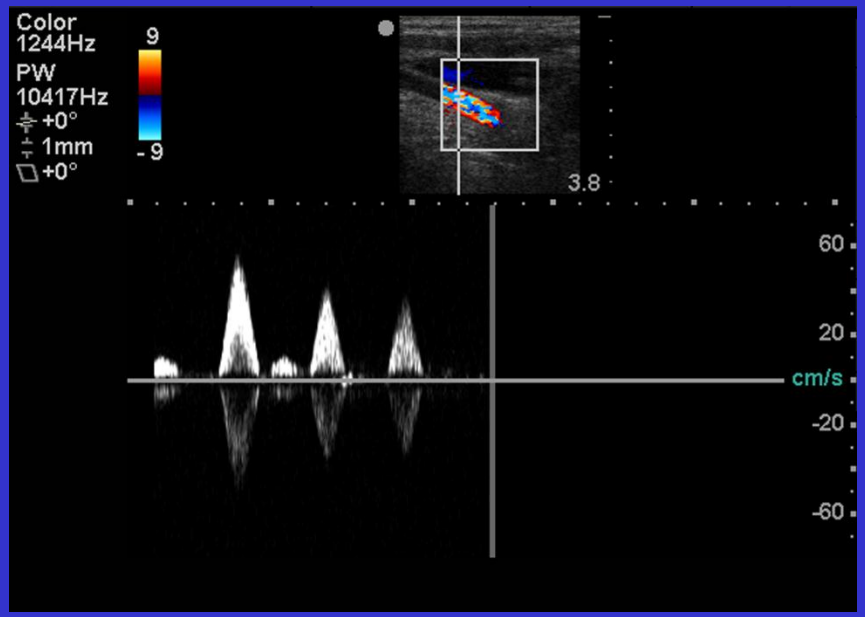
TTE in Resuscitation

- If you suspect ejection fraction is adequate check
- Ample evidence that peripheral pulse check is significantly limited
- Quick Doppler of carotids can be very helpful however



TTE in Resuscitation

- Normal carotid peak systolic velocities range from 55 to 100 cm/sec
- Blackshear WM, Phillips JD, Chikos PM et al Carotid artery velocity patterns in normal and stenotic vessels. *Stroke. 1980 Jan-Feb;11(1):67-71.*



TTE in Resuscitation

- Will occasionally see the exact cause of arrest
- Pericardial effusion, thrombus or other
- This patient was found down on sidewalk and brought in by "friends"
- Suspected of being sleepy?

TTE in Resuscitation

- Some inherent disadvantages
- Time to obtain useful image takes away from compressions
- Not all patients yield interpretable images
- It may be difficult to determine how accurate image is

TTE in Resuscitation

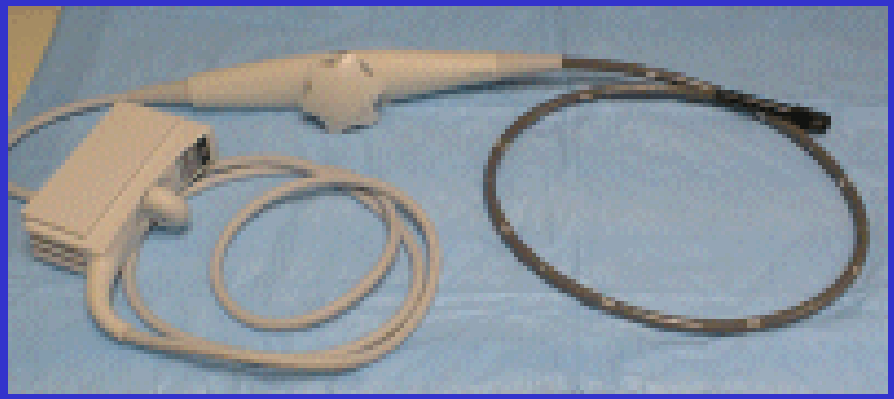
- Can get in the way of resuscitation efforts
- Frequently difficult to perform during good chest compressions
- Easy during bad compressions
- Harder to monitor compression effectiveness

TTE in Resuscitation

- In 10 to 20% of cases can see nothing useful at all
- Can move to Parasternal or apical
- But what about compressions?
- Sometimes even these options are not great

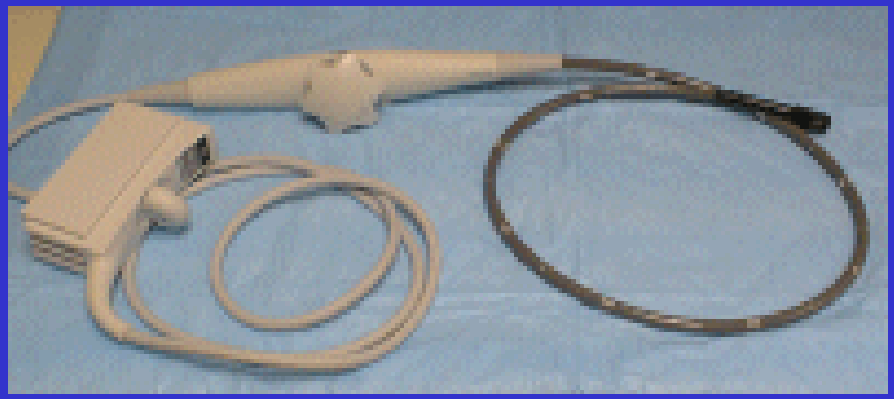
TEE Transducer

- Would like to cheat the limitations of TTE and find an accurate image that is rapidly obtained
- TEE seemed like a good way
- And it turns out it is



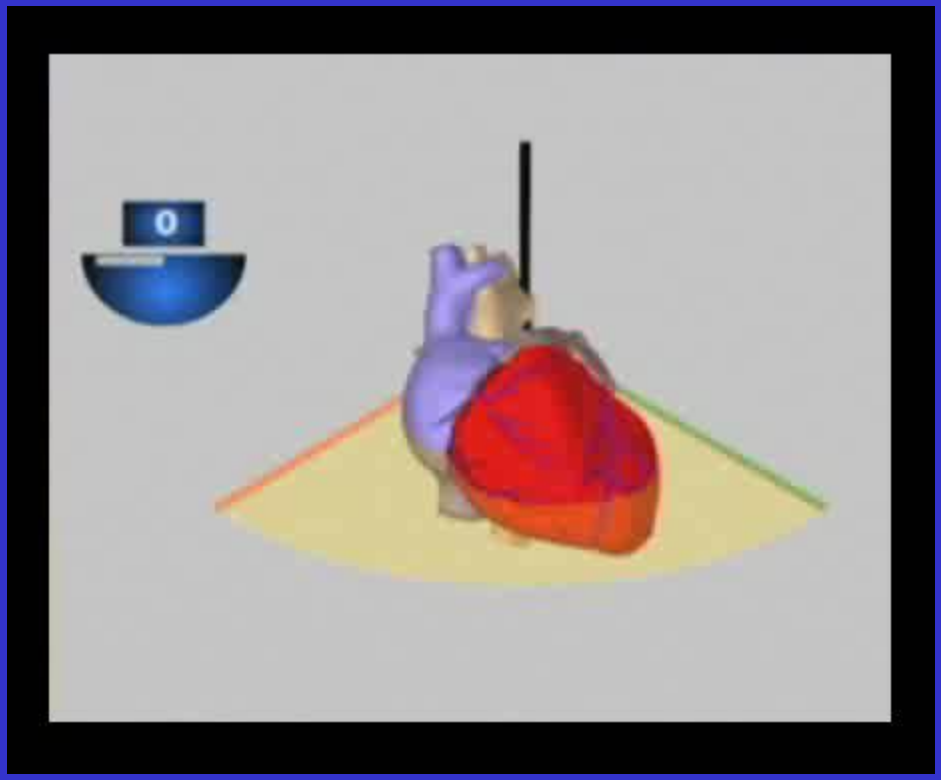
TEE in Resuscitation

- Some inherent advantages
- Probe is closer to heart
- Lung is not in the way and neither is adipose tissue
- Images are much clearer



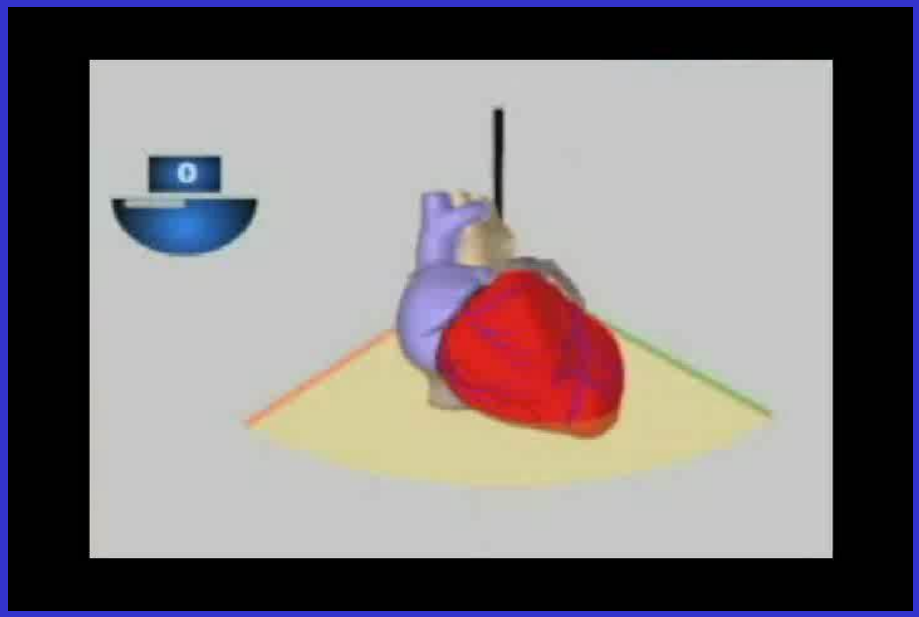
TEE in Resuscitation

- Manipulation of probe involves manually turning probe to a small degree only
- Considerable control afforded by mechanically and electronically turning head and crystals



TEE in Resuscitation

- Beam may be angled in almost any direction and scan throughout heart as well as associated structures
- Aortic arch is a structure typically not well visualized



TEE Transducer Controls

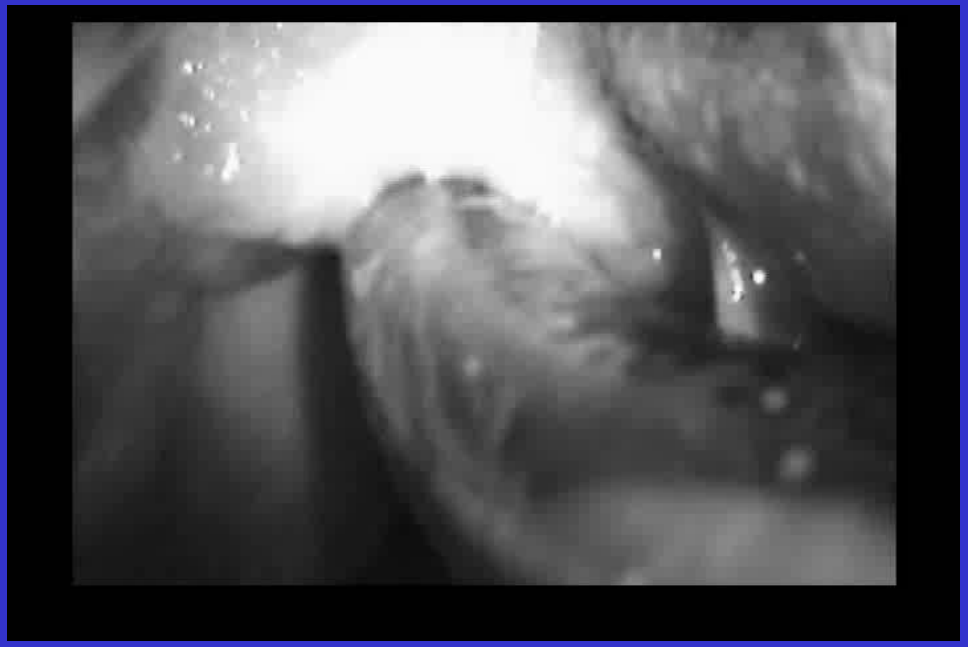
- Controls from simulator and a real transducer
- This is the simulator we will use today
- Controls on the actual probe we will try are also very similar

TEE in Resuscitation

- Probe insertion is easiest in the intubated patient
- Requires care in placing to avoid damaging structures, complications with placement are rare

TEE in Resuscitation

- Probe insertion is easiest in the intubated patient
- Requires care in placing to avoid damaging structures, complications with placement are rare



TEE in Resuscitation

- Probe insertion is easiest in the intubated patient
- Requires care in placing to avoid damaging structures, complications with placement are rare

TEE Safety in Resuscitation

- Can you perform full resuscitative efforts while using TEE?
- Could you damage esophagus with chest compressions?
- Will you cause heat injury to the esophagus with prolonged use?
- Can you shock someone with the probe in the esophagus?

TEE Safety in Resuscitation

- In general, a number of risks exist:
  - Oropharyngeal/Dental trauma
  - Esophageal Trauma
  - Gastric trauma/bleeding
  - Odynophagia
  - ETT malposition
  - Aspiration
  - Hemodynamic deterioration from sedation
- Unclear that such risks outweigh immediate problem at hand

TEE Safety in Resuscitation

- One of the largest studies to date suggests TEE is fairly safe
- Morbidity 0.2%
- **Mortality 0%**
- 7200 surgical patients undergoing peri-operative TEE

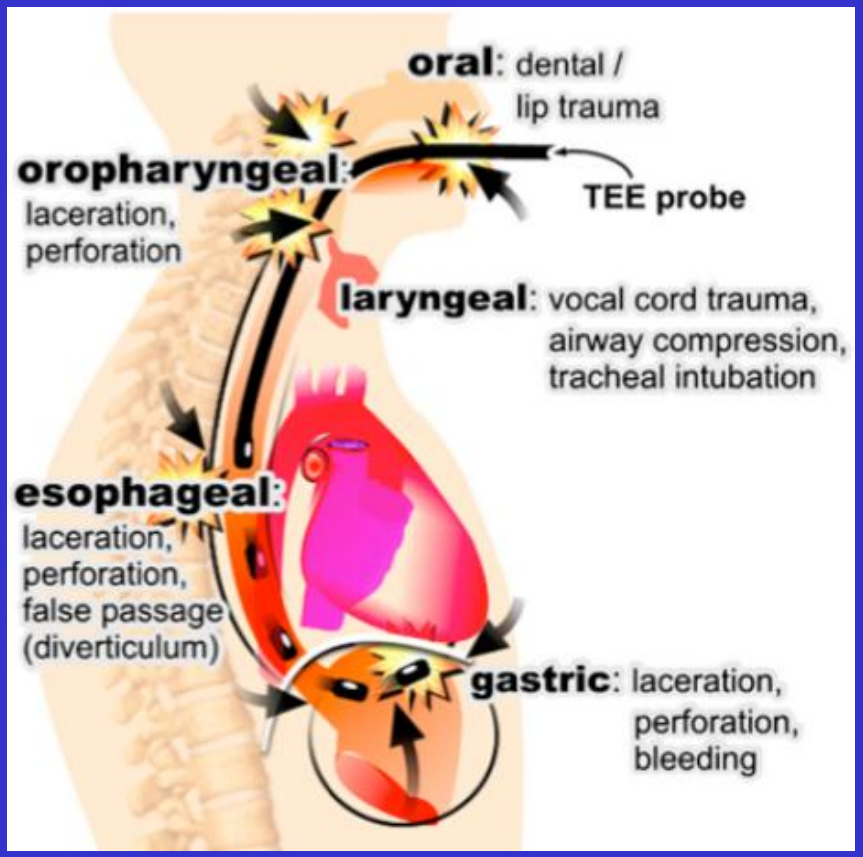
The Safety of Intraoperative Transesophageal Echocardiography: A Case Series of 7200 Cardiac Surgical Patients

Ian J. Kallmeyer, MB, ChB, Charles D. Collard, MD, John A. Fox, MD, Simon C. Body, MB, ChB, and Stanton K. Shernan, MD

Department of Anesthesiology, Perioperative and Pain Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts

TEE Safety in Resuscitation

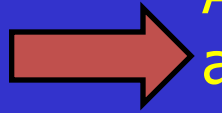
- Dental injury 0.03%
- Severe Odynophagia 0.1%
- Minor Pharyngeal Bleeding 0.01%
- ETT malposition 0.03%



TEE Safety in Resuscitation

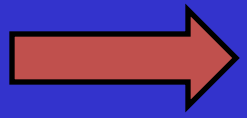
- Can you perform full resuscitative efforts while using TEE?
- Could you damage esophagus with chest compressions?
- Will you cause heat injury to the esophagus with prolonged use?
- Can you shock someone with the probe in the esophagus?

- Yes, done in the OR all of the time, no evidence of injury



- Appears to be very rare, it is a pliable organ

- No evidence of thermal burns, probe has sensors and good minimize heat



- Yes, the probe is electrically isolated, but manufacturers will tell you not idea just like using water bath for MSK

Clean Your Probe

- Infection control is critical
- Manual cleaning after use
- Disinfection per hospital protocol with glutaraldehyde or newer agent/process
- Some slick ones coming on the market

Standard TEE Views

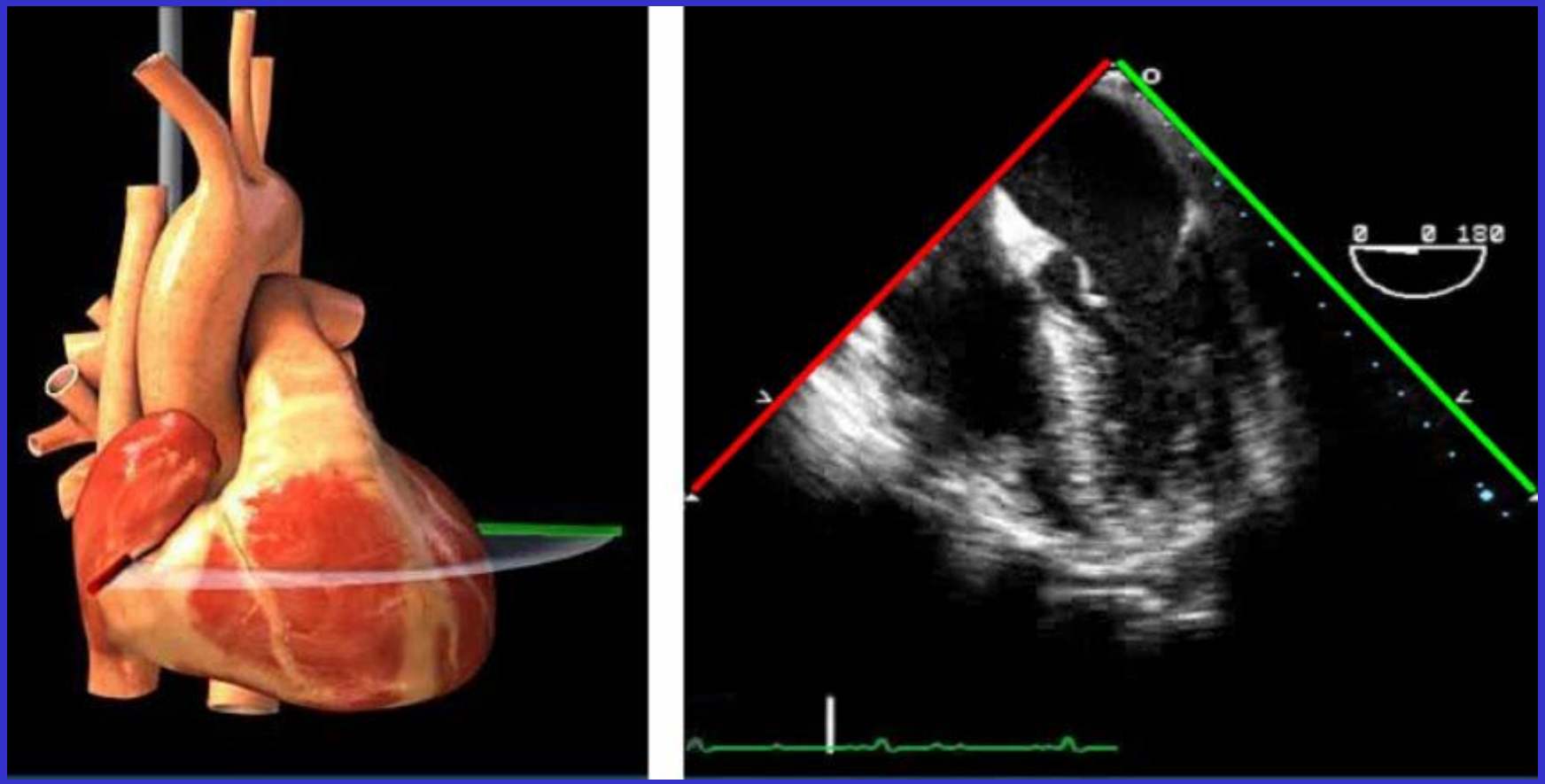
- There are as many as 20 described TEE views
- Some are harder to get than others
- Several may be quite challenging
- In resuscitation most additional views add little
- We are really speaking of focused TEE (bad word in some circles)
- However, simple and better than complex, when possible
- Trans-gastric views can be utilized as well as esophageal
- For resuscitative efforts it is probably easiest to focus on four or five views
- Frequently, one view can be used for patients in CPR to monitor progress

Standard TEE Views

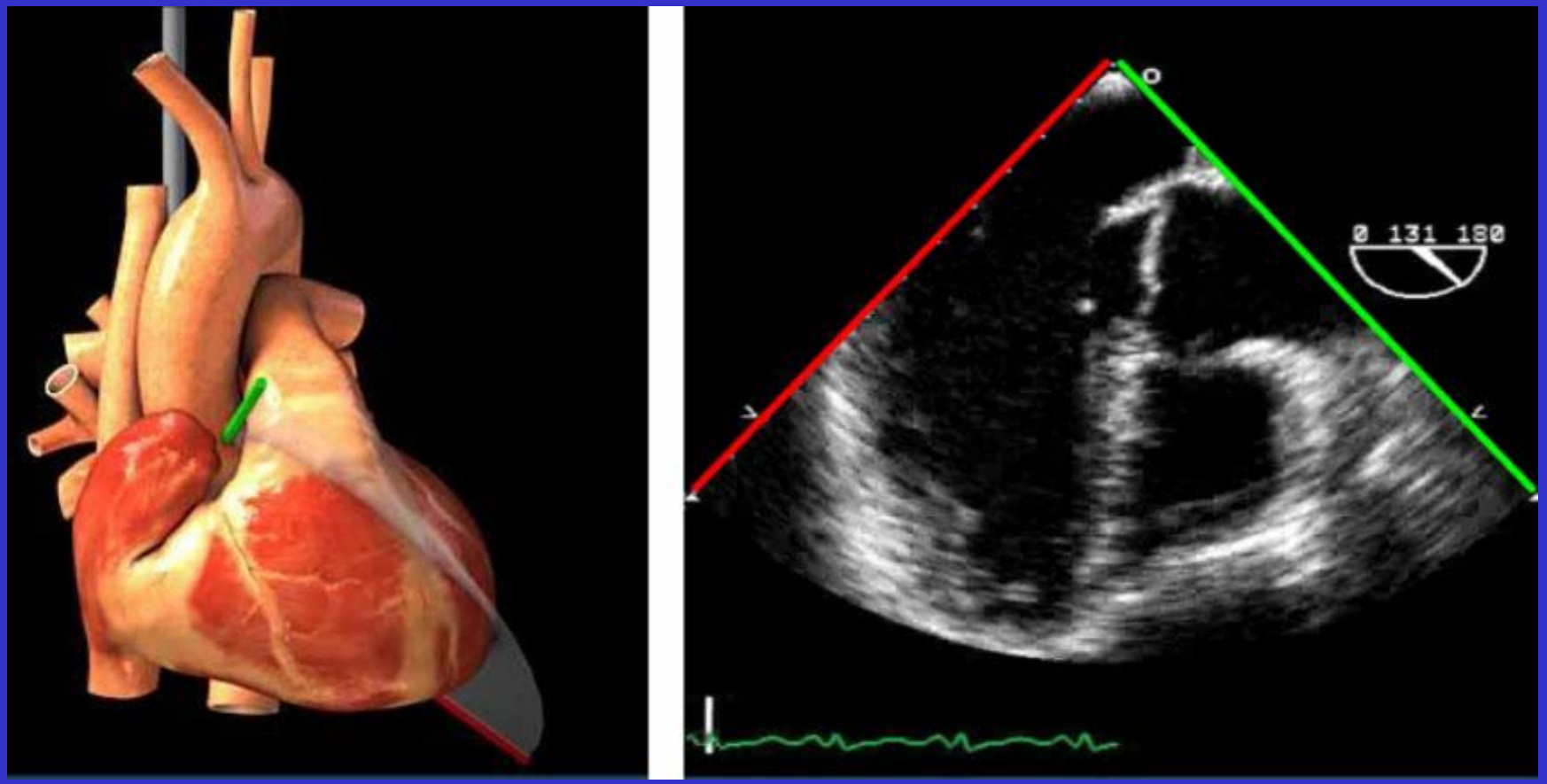
- Are there portions of the heart we will not evaluated completely with a focused approach?
- Of course
- Nothing stops you from doing more, in time

- Be careful about indication creep…
- Focus on resuscitative uses first and then with additional training and experience you can expand as needed

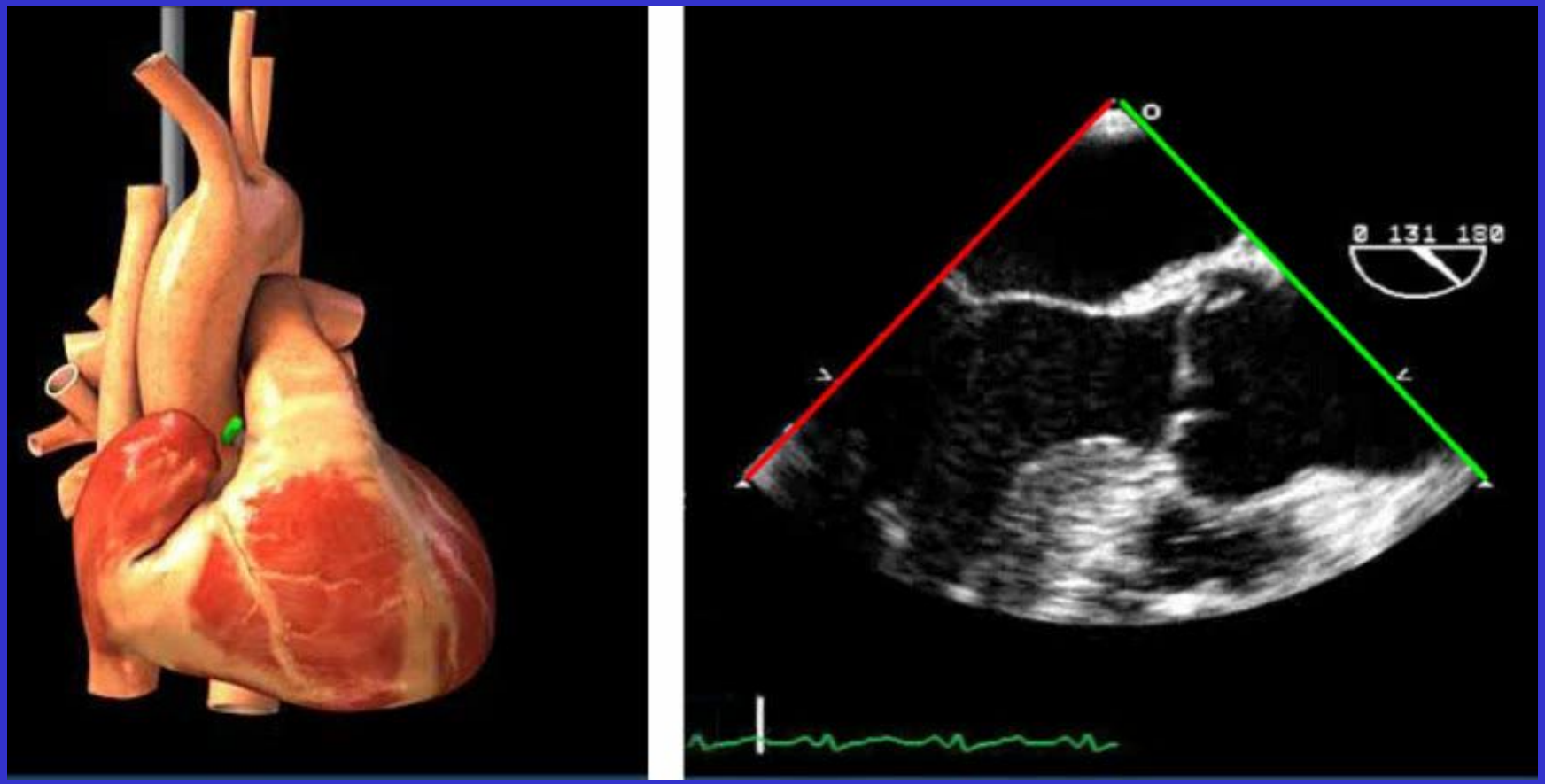
Mid Esophageal 4 Chamber



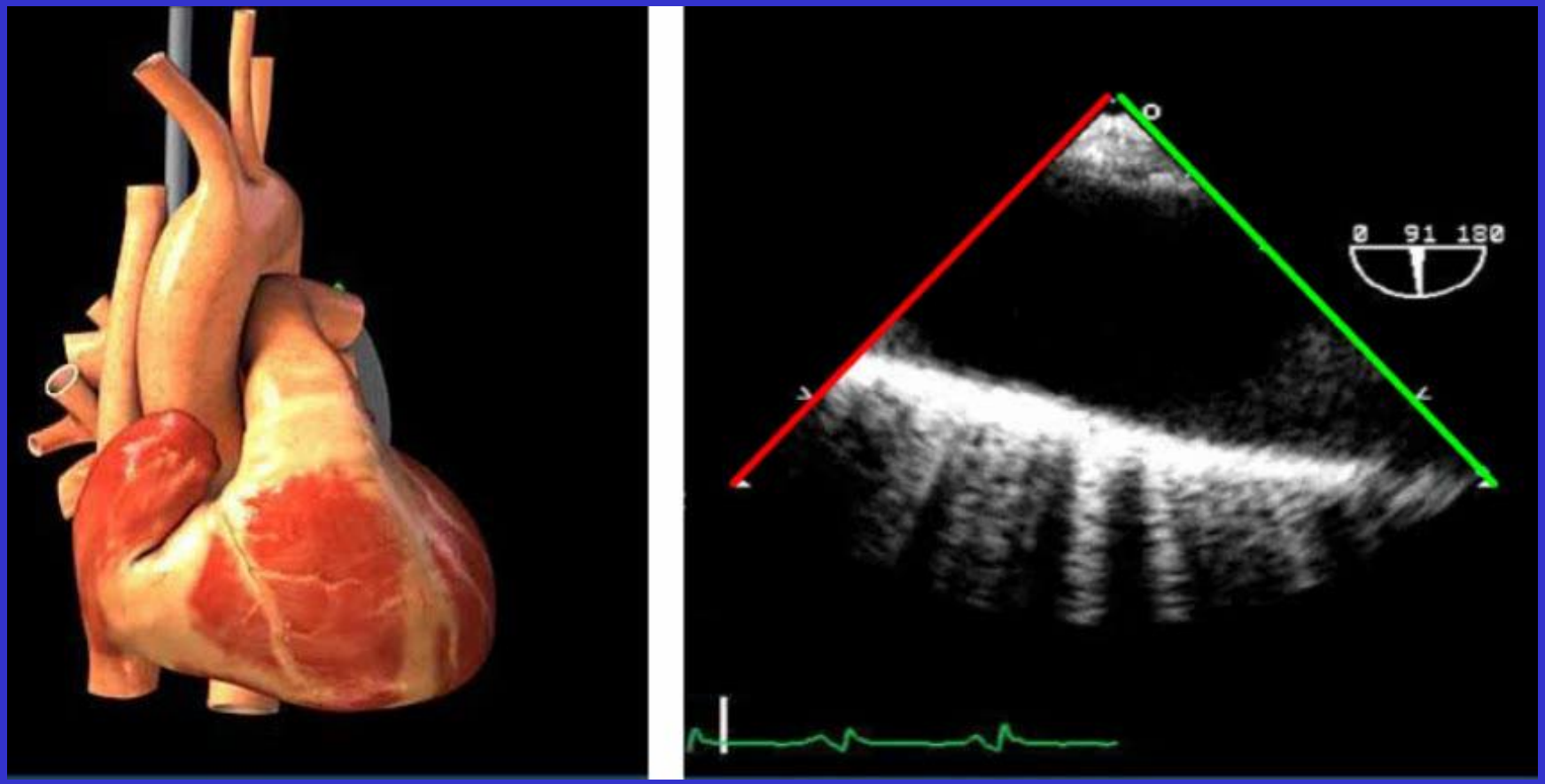
Mid Esophageal LAX



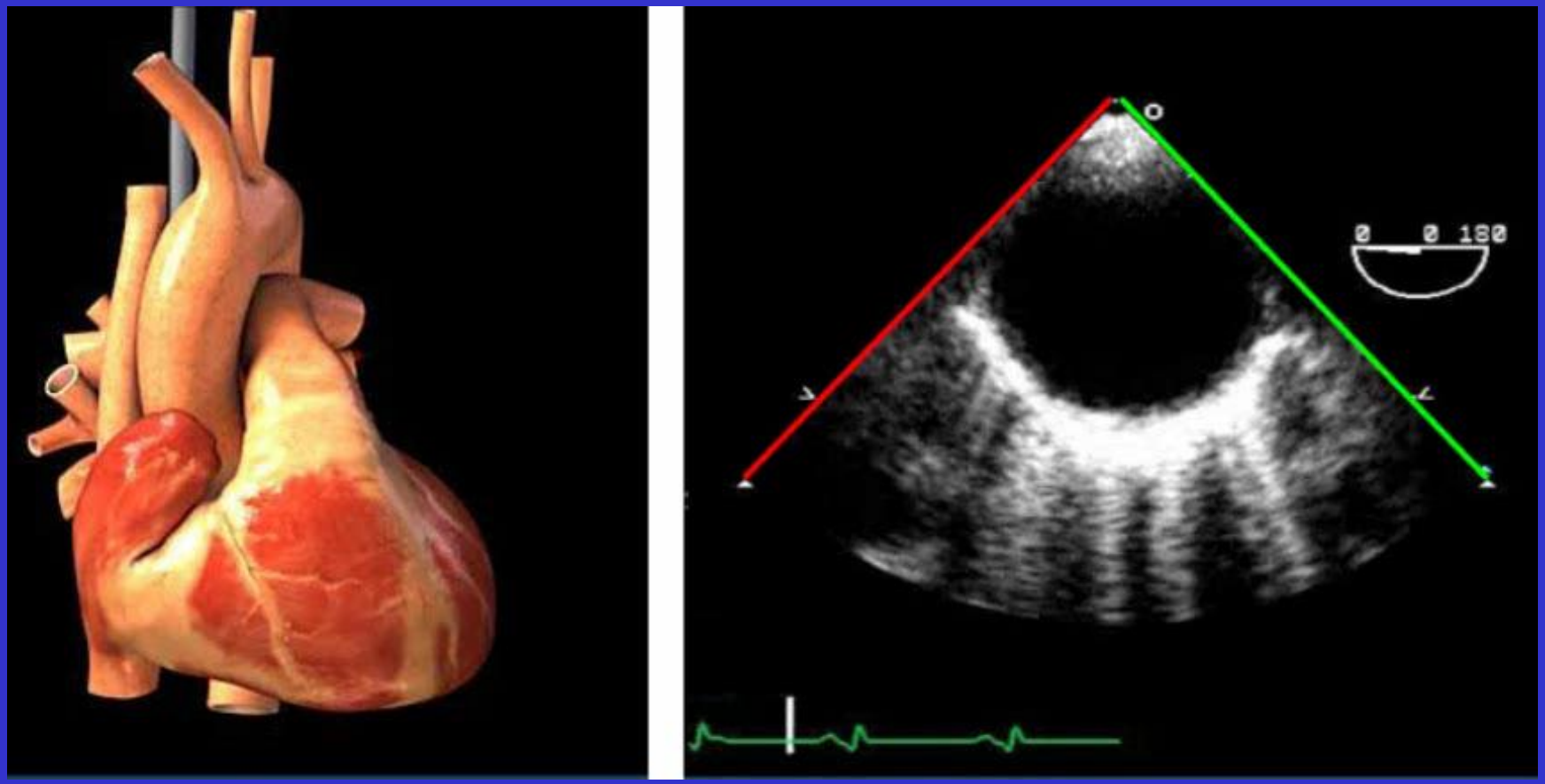
Mid Esophageal Aortic Valve LAX



Mid Esophageal Descending Aortic LAX



Mid Esophageal Descending Aortic SAX

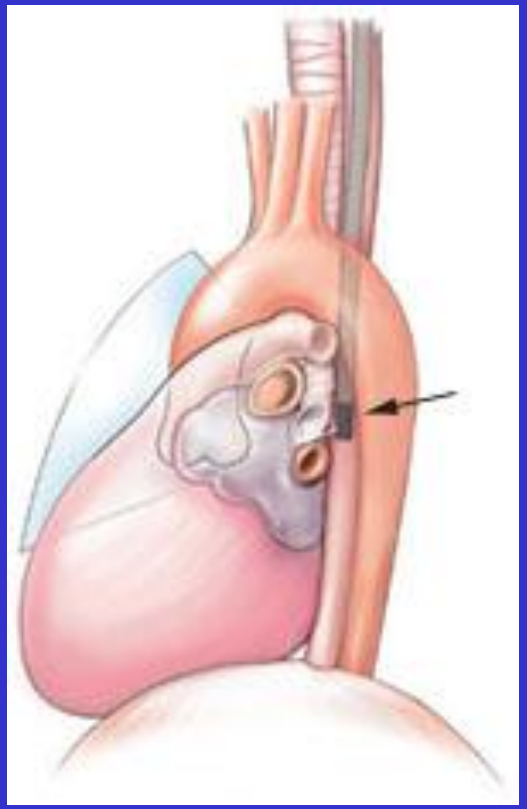


TEE in Resuscitation

- Pathology poorly seen in TTE may be much clearer in TEE
- Much more likely to get detailed information
- Less likely to have uninterruptable echo

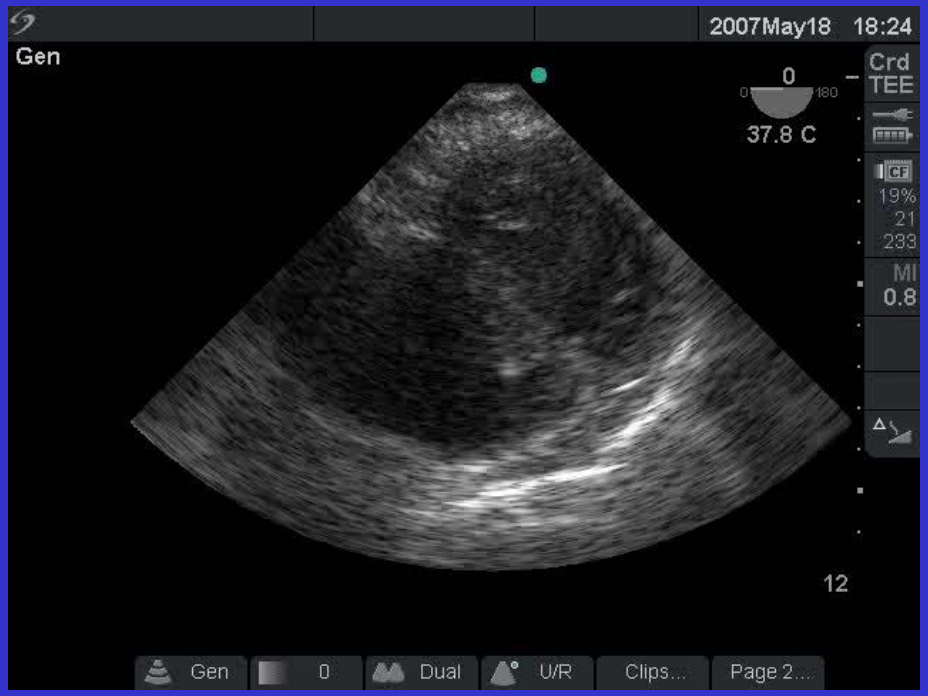
TEE in Resuscitation

- Once placed, the probe can be left in as a continuous monitor
- Remember limiting exposure…
- Other tasks can be performed like central line or code management with occasional looks at monitor
- Can shock with probe in place



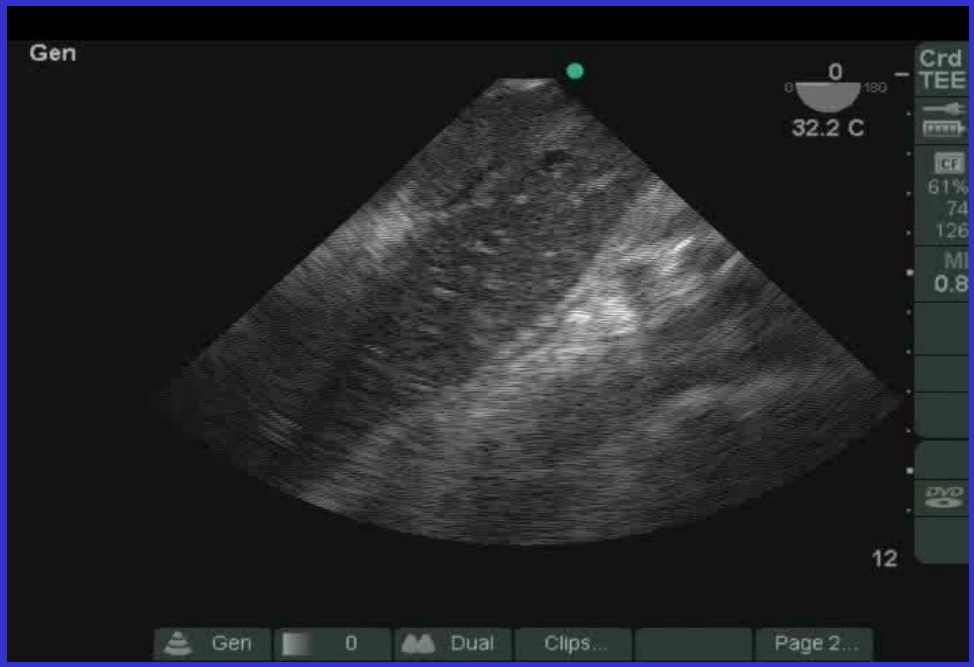
TEE in Resuscitation

- Once placed, the probe can be left in as a continuous monitor
- Remember limiting exposure…
- Other tasks can be performed like central line or code management with occasional looks at monitor
- Can shock with probe in place



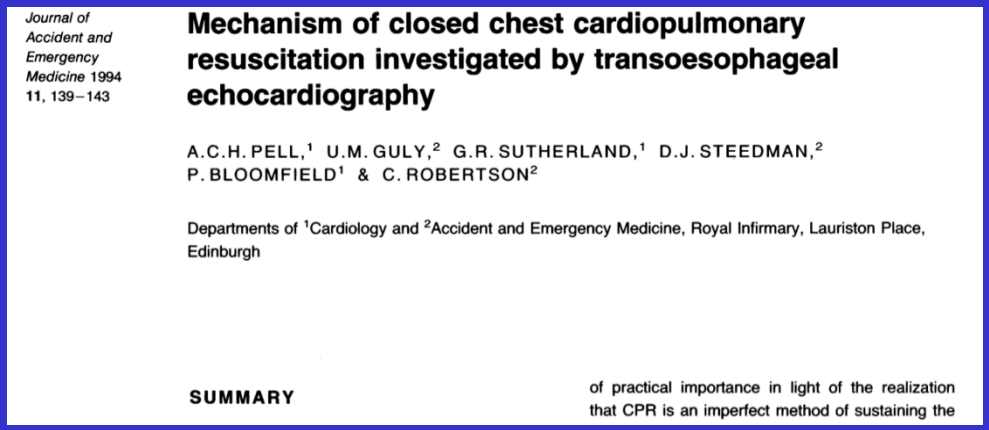
TEE in Resuscitation

- Allows great monitoring of chest compression effectiveness
- Good chest compressions are a rare thing



TEE in Resuscitation

- Effectiveness of CRP monitoring has been studied before
- Investigators were able to image the ventricles and estimate if good chest compressions were being delivered



Journal of Accident and Emergency Medicine 1994 11, 139–143

Mechanism of closed chest cardiopulmonary resuscitation investigated by transoesophageal echocardiography

A.C.H. PELL,[1] U.M. GULY,[2] G.R. SUTHERLAND,[1] D.J. STEEDMAN,[2] P. BLOOMFIELD[1] & C. ROBERTSON[2]

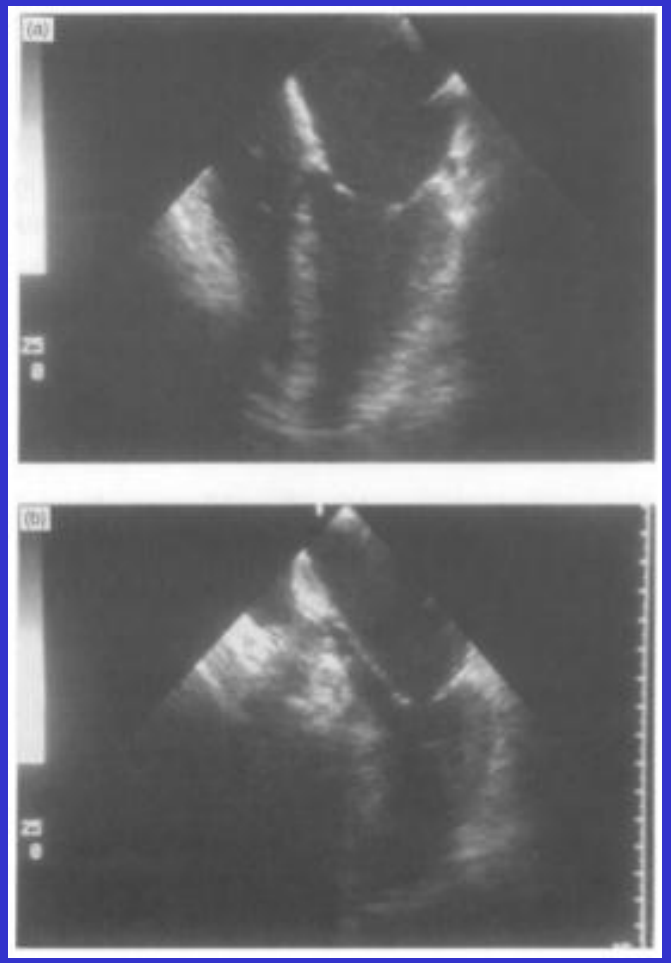
Departments of [1]Cardiology and [2]Accident and Emergency Medicine, Royal Infirmary, Lauriston Place, Edinburgh

SUMMARY

of practical importance in light of the realization that CPR is an imperfect method of sustaining the

TEE in Resuscitation

- The top image shows the relaxation
- Bottom image shows ventricles during compression
- Not all chest compressions are equal
- Also used CW measurements

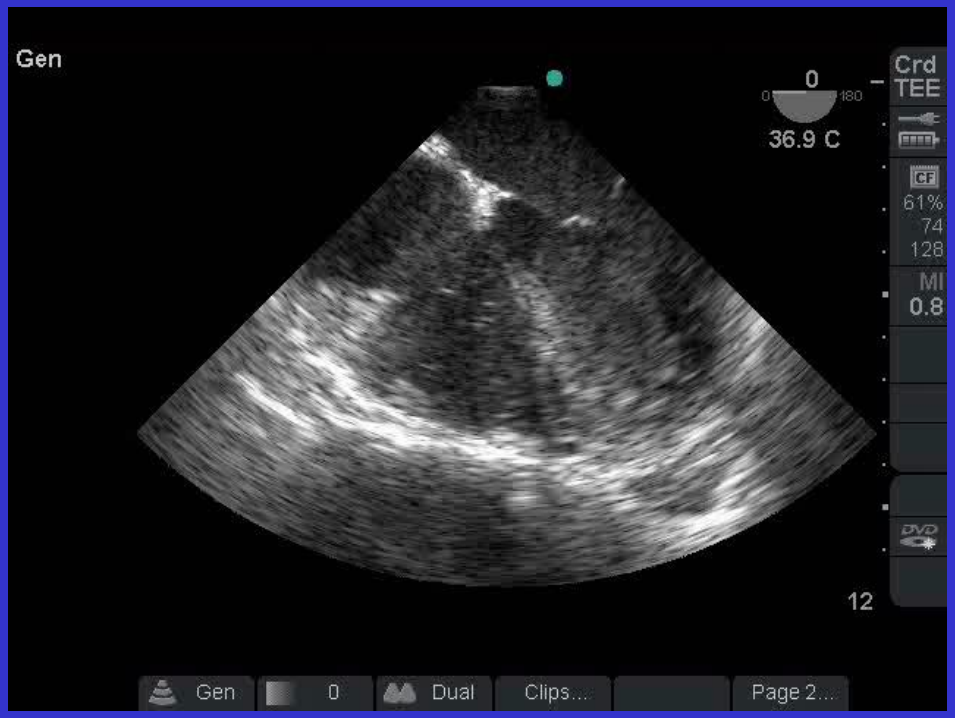


Is Chest Compression Monitoring Necessary?

- Not with this device
- However, humans should not being doing chest compressions
- Until they are removed from the equation, they need to be watched closely

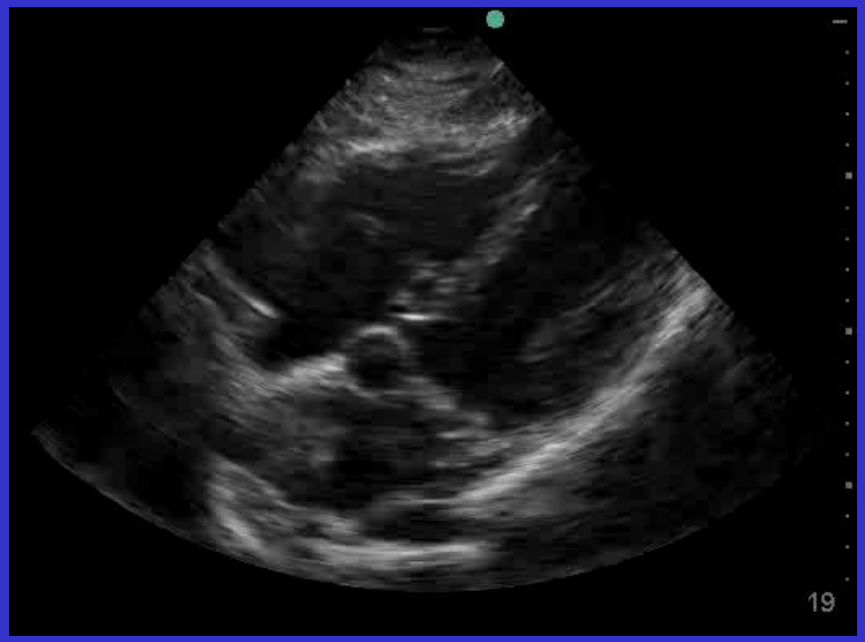
TEE in Resuscitation

- Time for echo checks/pulse checks greatly reduced
- Monitored from chair in corner of room
- Remember, the AHA and European council guidelines urge little break time from quality compressions

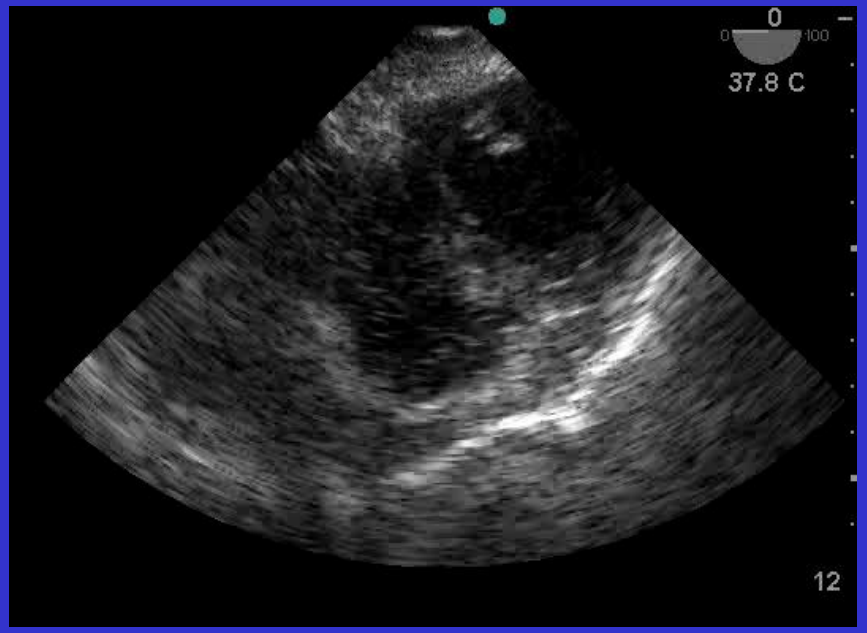


TTE and Rhythm Determination

- You have all seen the flat-line on the monitor that is actually fine v-fib
- TTE is great for picking this up
- However, sometimes the fibrillation is too fine to discern on TTE

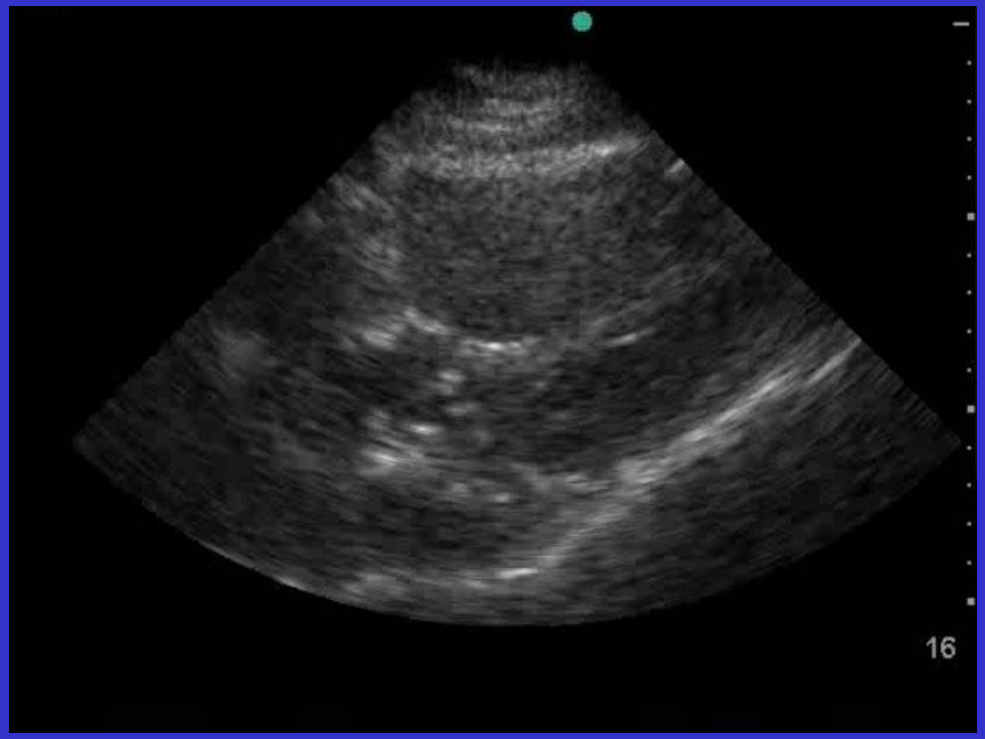


TEE and Rhythm Determination



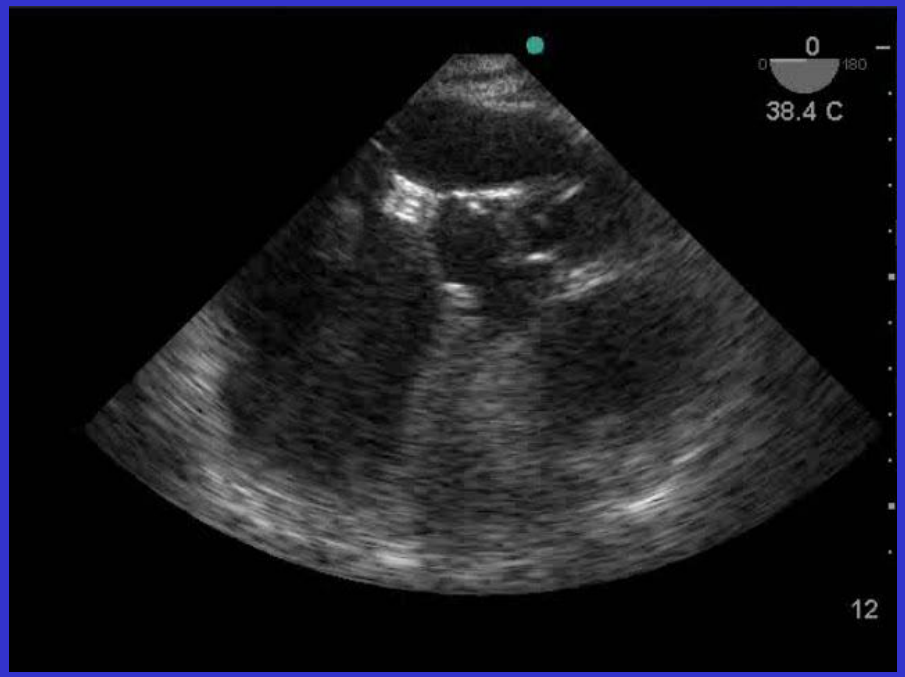
TEE in Resuscitation

- Young female collapsed at restaurant
- Arrives in PEA
- TTE provides some helpful information



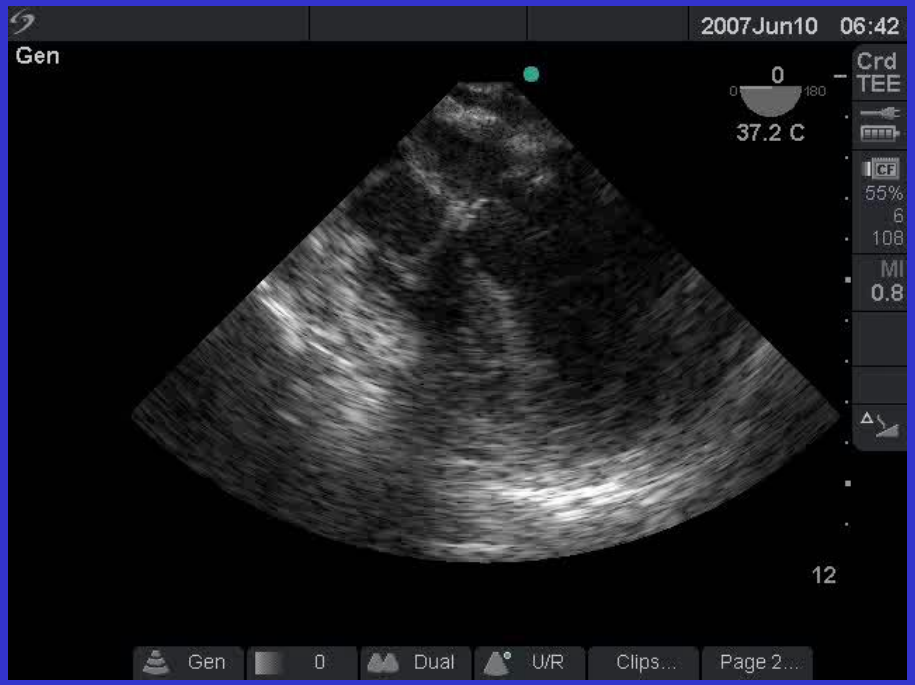
TEE in Resuscitation

- No obvious cause is seen
- Patient poorly responsive to resuscitation efforts
- TEE provides some additional information



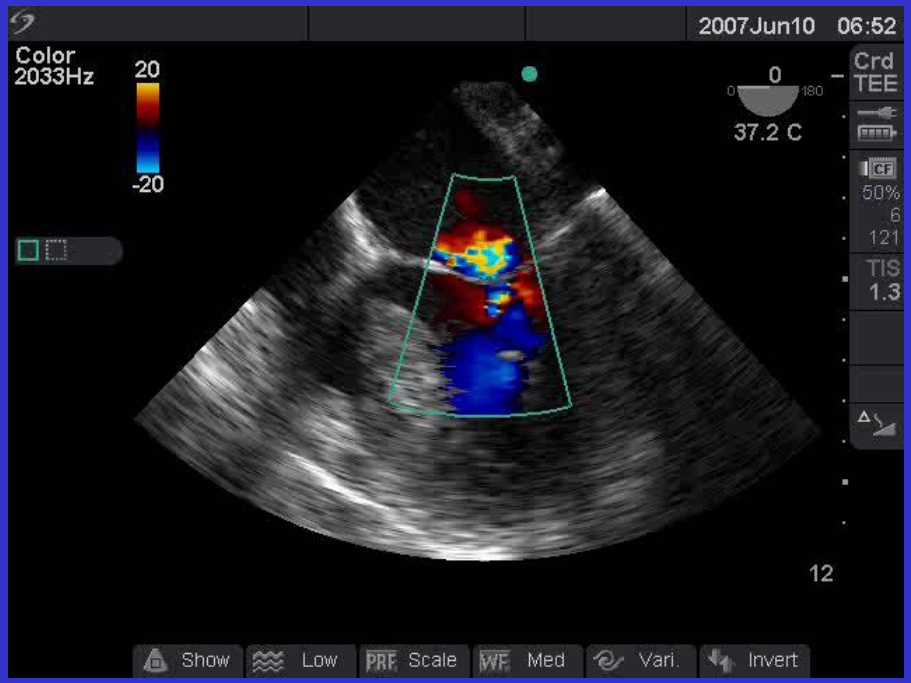
TEE in Resuscitation

- Monitoring chest compressions
- Unless an automated device is used, compressions can vary significantly
- 73 year old healthy patient with negative work up

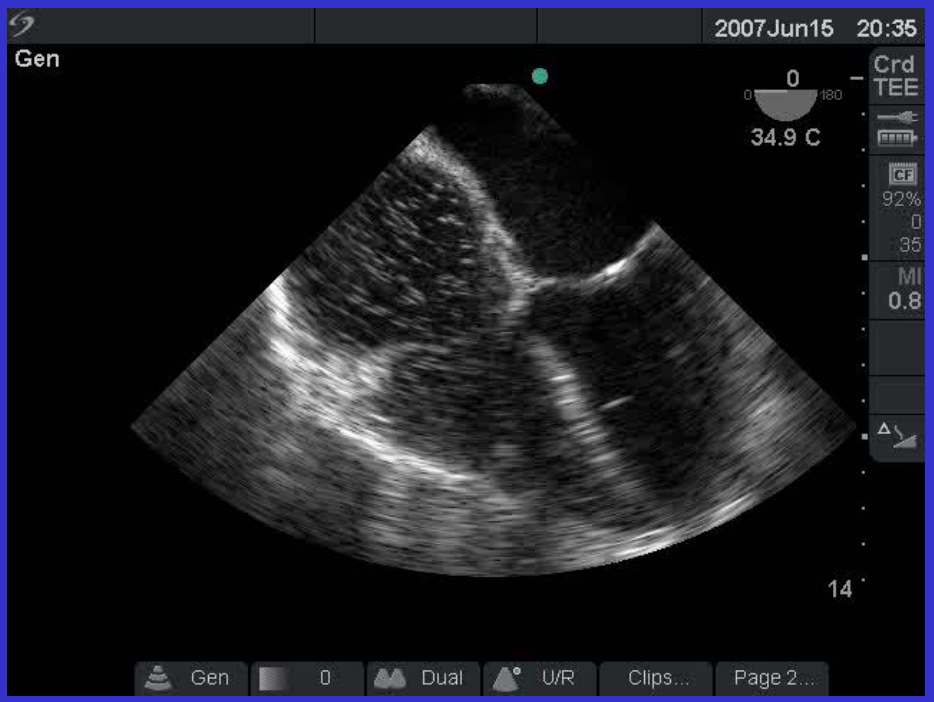


TEE in Resuscitation

- Closer look at the chambers reveals the problem
- Right ventricle appears abnormal, could not tell from TTE

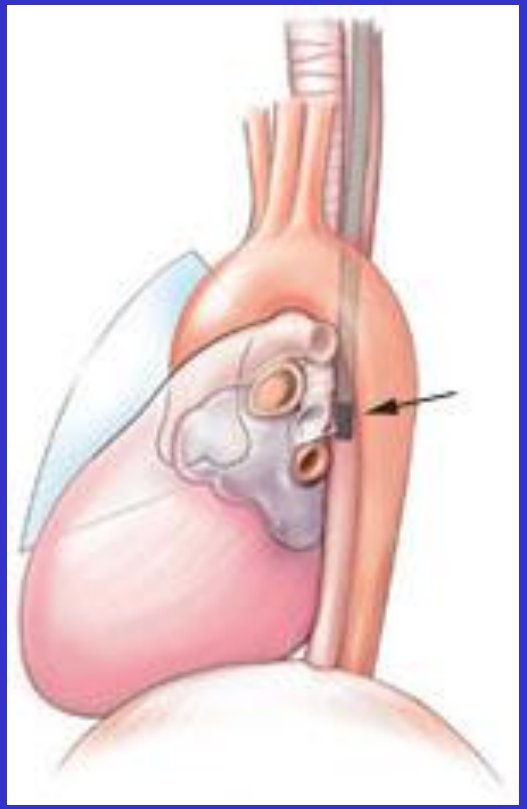


TTE vs TEE in Resuscitation



TEE in Resuscitation

- Inherent disadvantages as well
- Price is a big one, typically $40,000 +/- $5,000
- Requires additional training
- But for focused application can do focused training



Time Are Changing

- A lower cost TEE is possible and already available
- One company makes a rudimentary small diameter transducer
- Disposable
- Very low cost comparatively

Time Are Changing

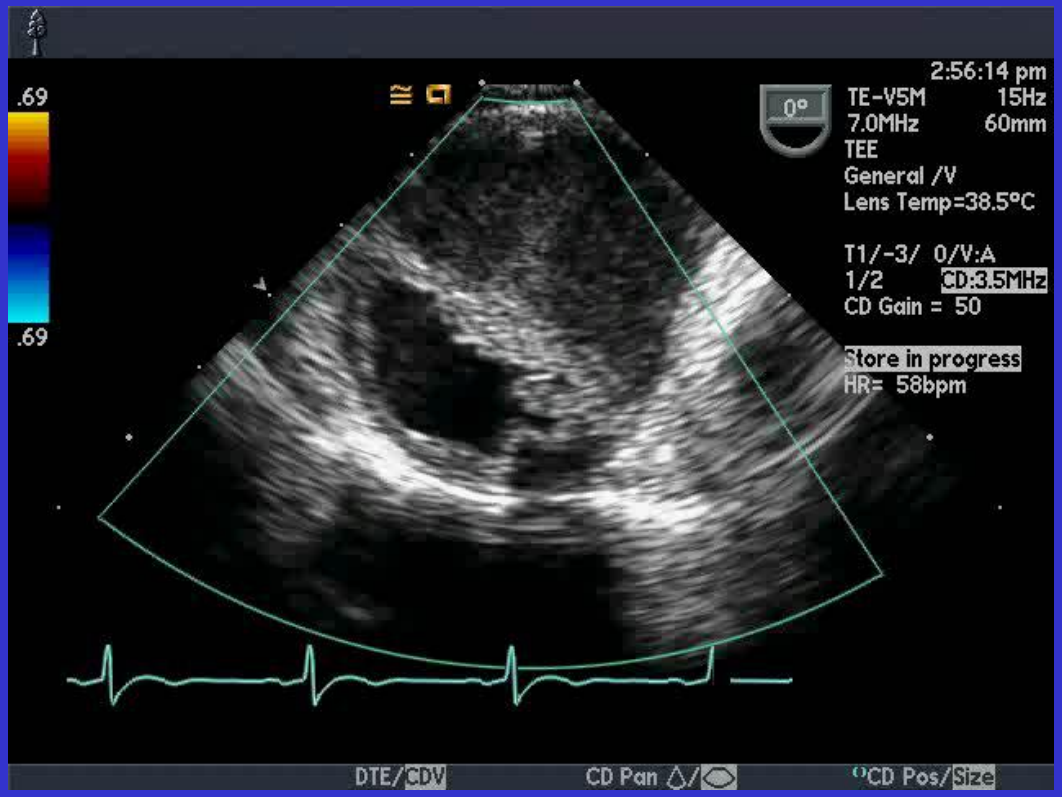
- Discussion with multiple manufacturers
- All responded they have interest and capability
- May see point of care TEE in the future

Other Causes Found on TEE

- May encounter other causes of hypotension or arrest
- TEE is well suited for many of these
- TTE may have significant limitations
- Ruptured papillary muscle can lead to decompensation

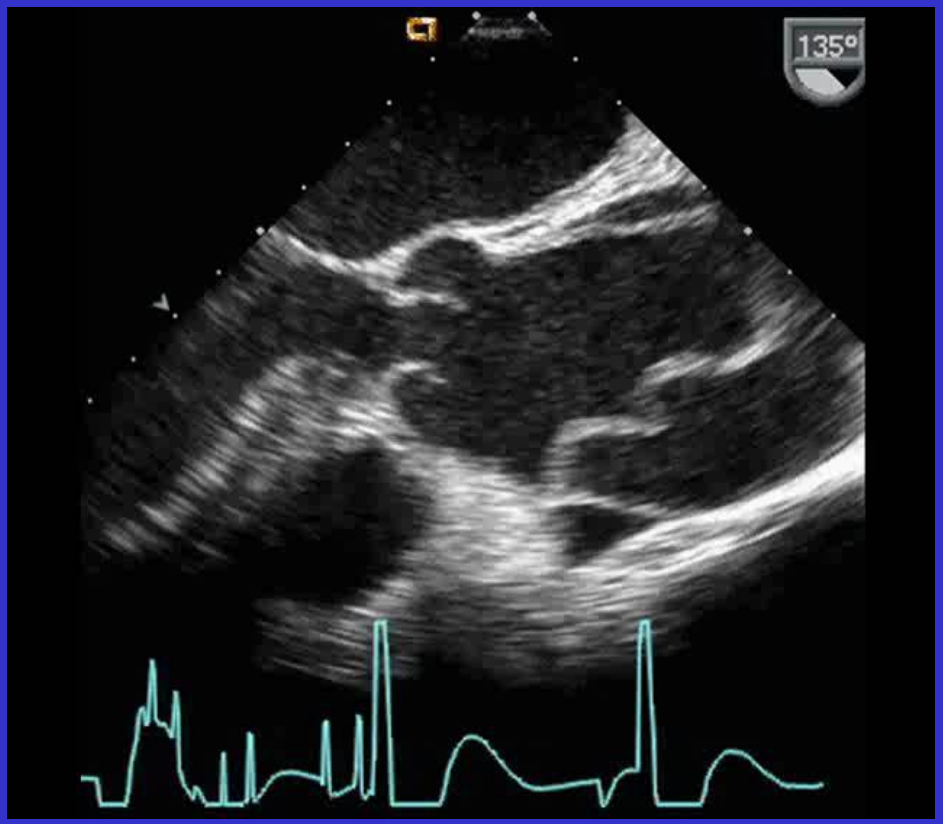
Other Causes Found on TEE

- The dreaded and difficult to detect aortic dissection
- TEE is a choice imaging study



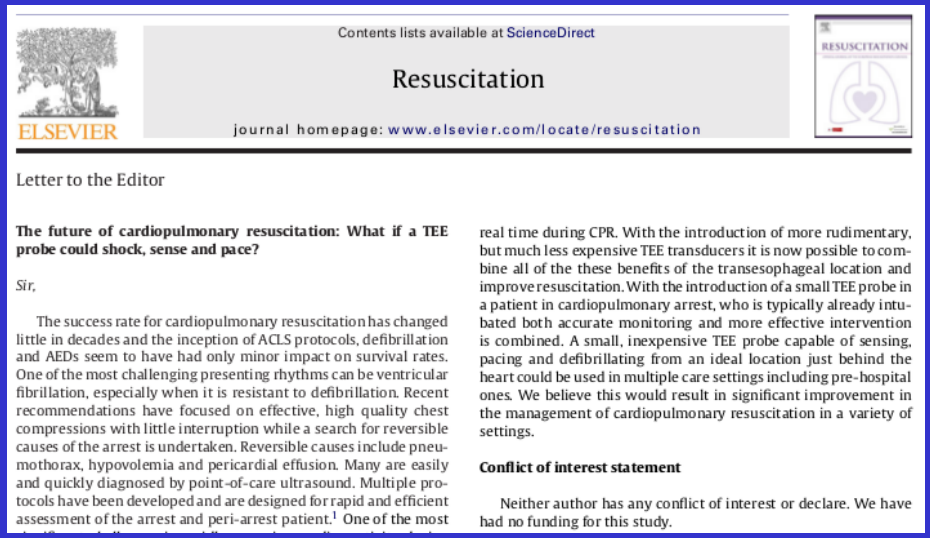
TEE in Resuscitation

- Even the basic views obtainable with TTE are more easily interpretable and allow for higher accuracy



Can TEE do More in Resuscitation?

- TEE seems to offer so many advantages
- Can it do more for us?
- Is there more we can ask for in the future?
- We asked: "What if a TEE probe could shock, sense and pace?"



Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Letter to the Editor

The future of cardiopulmonary resuscitation: What if a TEE probe could shock, sense and pace?

Sir,

The success rate for cardiopulmonary resuscitation has changed little in decades and the inception of ACLS protocols, defibrillation and AEDs seem to have had only minor impact on survival rates. One of the most challenging presenting rhythms can be ventricular fibrillation, especially when it is resistant to defibrillation. Recent recommendations have focused on effective, high quality chest compressions with little interruption while a search for reversible causes of the arrest is undertaken. Reversible causes include pneumothorax, hypovolemia and pericardial effusion. Many are easily and quickly diagnosed by point-of-care ultrasound. Multiple protocols have been developed and are designed for rapid and efficient assessment of the arrest and peri-arrest patient.[1] One of the most

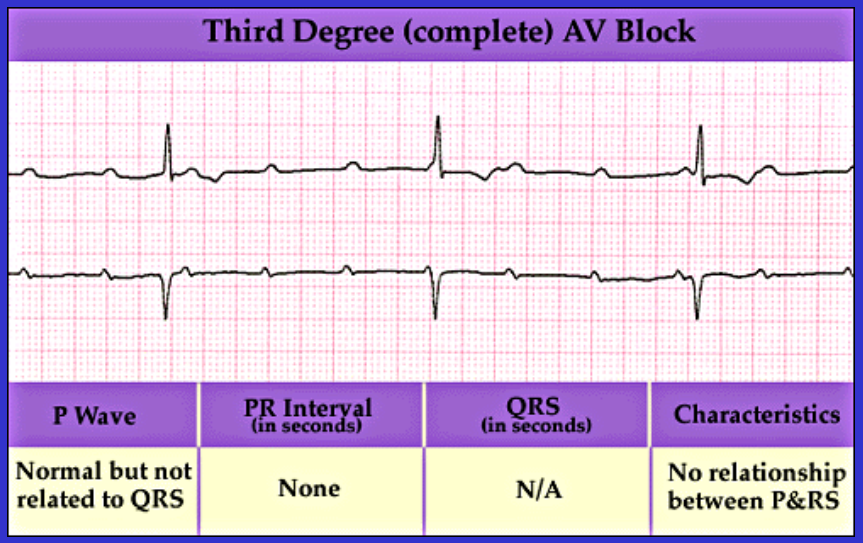
real time during CPR. With the introduction of more rudimentary, but much less expensive TEE transducers it is now possible to combine all of the these benefits of the transesophageal location and improve resuscitation. With the introduction of a small TEE probe in a patient in cardiopulmonary arrest, who is typically already intubated both accurate monitoring and more effective intervention is combined. A small, inexpensive TEE probe capable of sensing, pacing and defibrillating from an ideal location just behind the heart could be used in multiple care settings including pre-hospital ones. We believe this would result in significant improvement in the management of cardiopulmonary resuscitation in a variety of settings.

Conflict of interest statement

Neither author has any conflict of interest or declare. We have had no funding for this study.

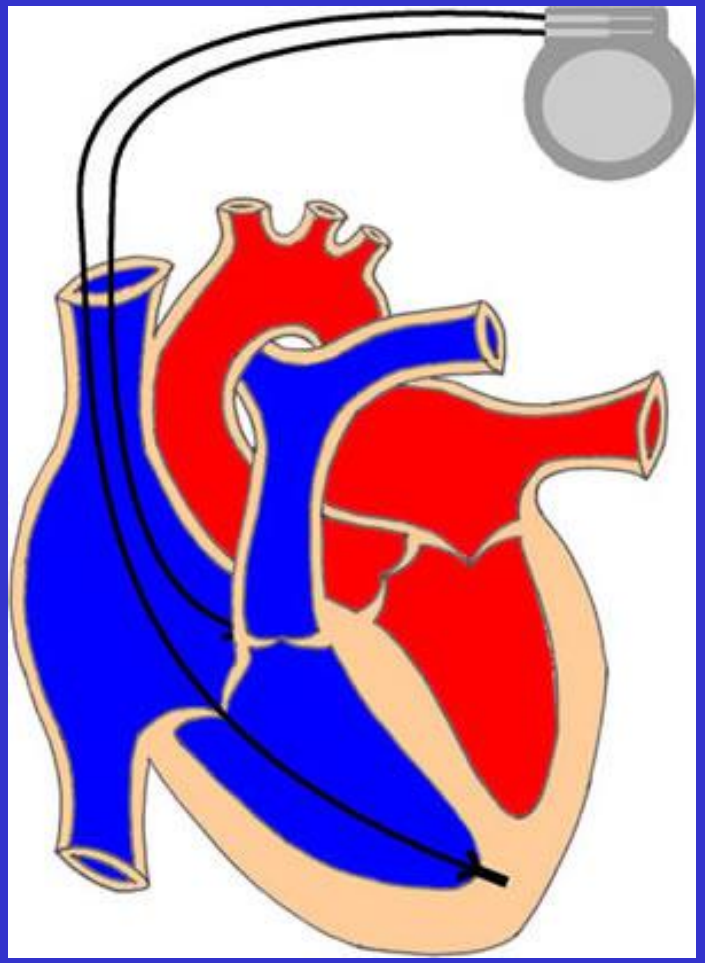
Severe Bradycardia

- Symptomatic bradycardia or asystolic pauses can present acutely in the critical care setting
- Degeneration to arrest possible is a threat
- Some patients respond to meds others will need electrical pacing
- Can be life saving



Treatment Options

- You have several options
- Transcutaneous pacing
- Put in pacer blindly…
- Put in pacer using traditional method with fluoroscopy

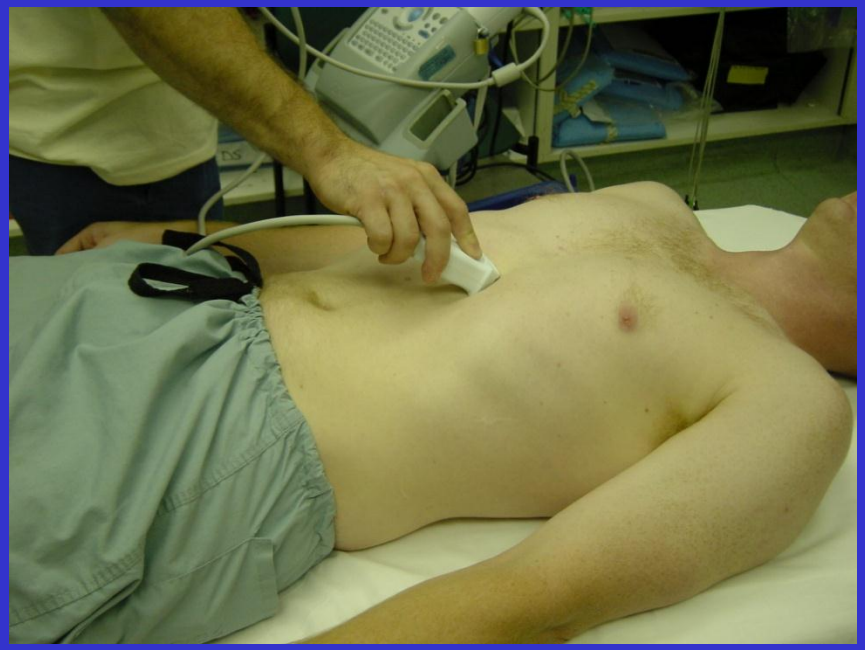


Placement Options

- You have several options
- Transcutaneous pacing
- Put in pacer blindly…
- Put in pacer using traditional method with fluoroscopy

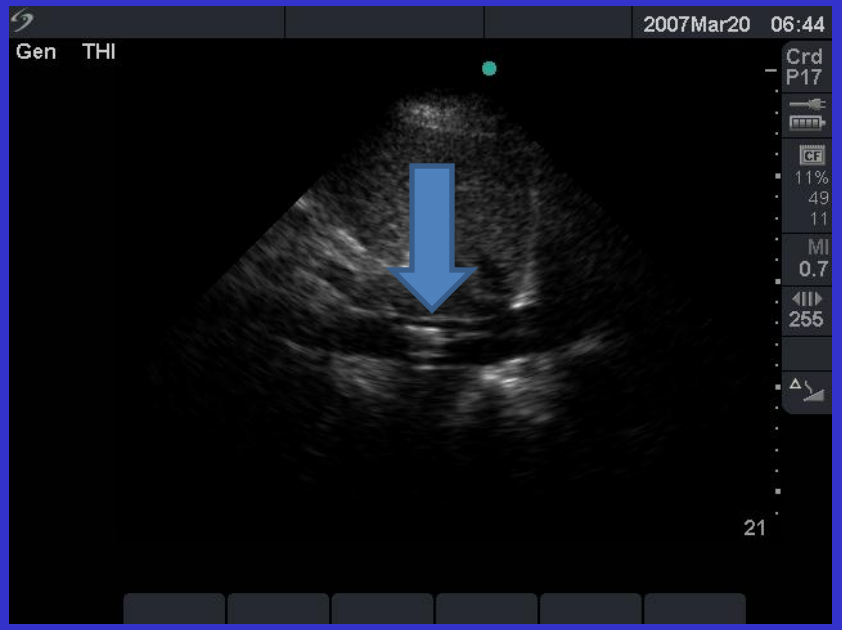
Placement Options

- Ultrasound is a great option
- Can visualize pacer when it enters the right atrium
- Can also see if it goes astray



Placement Options

- Can guided directly and see when you are off course
- Rapidly find when it is going down the IVC and can adjust



Placement Results

- 60 patients received US guided trans-venous pacemaker placement over a 7 year period
- All patients were unstable and none were excluded from analysis due to incomplete data
- EPs were successful in placing the pacemaker into the right ventricle in 59 (98%) patients
- Successfully paced 50 (83%) patients

Placement Results

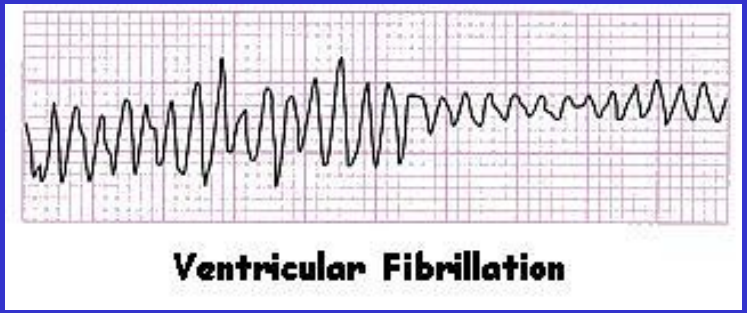
- The most frequent imaging window used was subxiphoid
  - followed by apical four chamber
- Reasons for pacing failure included
  - 2 cases of equipment failure (one was successfully corrected and patient paced)
  - severe beta blocker overdose
  - severe ischemia

Placement Results

- Causes of bradycardia included
  - third degree block
  - hyperkalemia
  - ischemia
  - overdose
  - tachy-brady syndrome
  - unknown causes
- US guidance allowed successfully placement in 98%

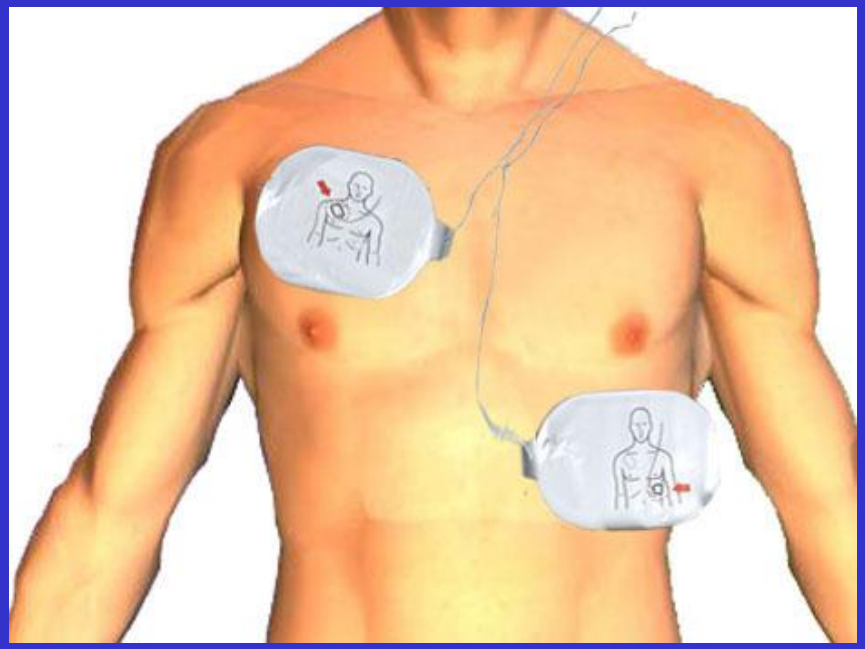
Ventricular Fibrillation

- Very bad thing
- Meds sometimes work
- Sometimes not
- May have to shock
- Long list of factors that effect the amount of energy delivery to the heart



Can You Defibrillate or Pace This Chest?

- Then answer is probably yes
- This patient may not tolerate external pacing well while awake, but it will probably work well
- Not an issue at all when intubated post arrest

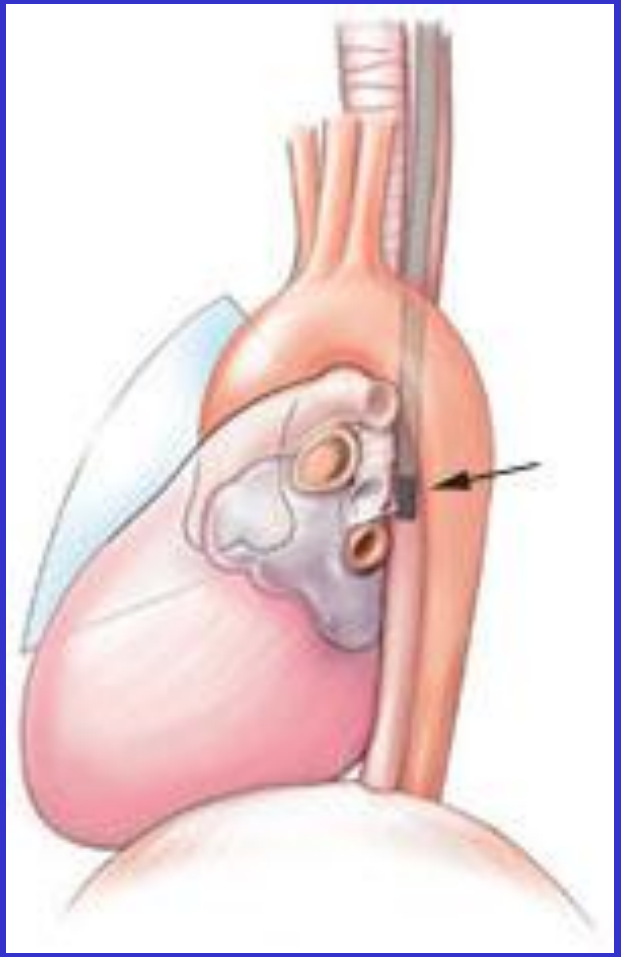


Can You Defibrillate or Pace This Chest?

- Really?
- Probably less likely
- Perfect specimen for cardiac arrest
- How to you shock effectively?
- How do you pace effectively

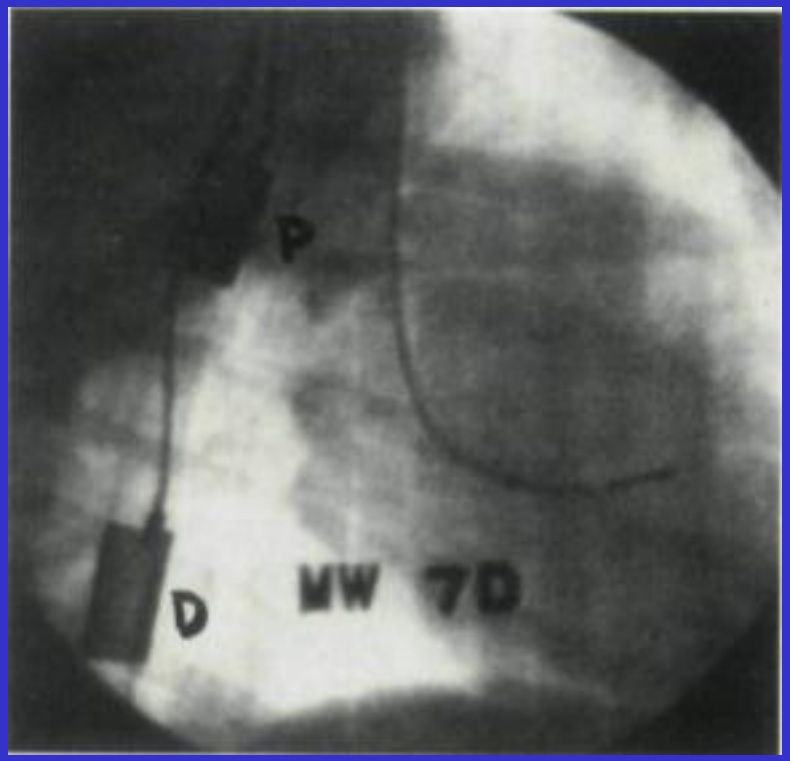
TEE and Defibrillation

- Perfect location
- TEE probe sits right behind the heart
- What do you know from shocking during thoracotomy?
- Less energy is required
- More effective?



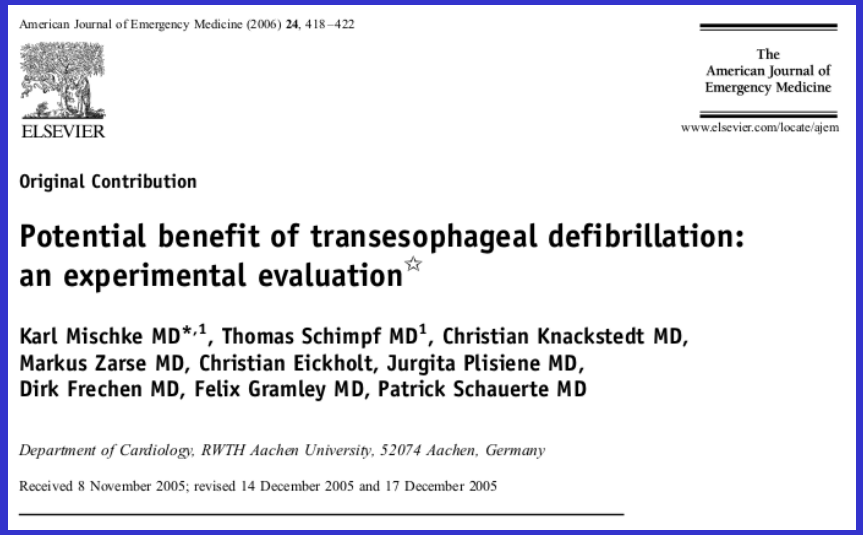
TEE and Defibrillation

- Perfect location
- TEE probe sits right behind the heart
- What do you know from shocking during thoracotomy?
- Less energy is required
- More effective?



TEE and Defibrillation

- Turns out this is not a new concept
- Has been tried before
- Experimented with defibrillating from TEE probe in the laboratory setting



American Journal of Emergency Medicine (2006) 24, 418–422

ELSEVIER

The American Journal of Emergency Medicine

www.elsevier.com/locate/ajem

Original Contribution

Potential benefit of transesophageal defibrillation: an experimental evaluation☆

Karl Mischke MD*,[1], Thomas Schimpf MD[1], Christian Knackstedt MD, Markus Zarse MD, Christian Eickholt, Jurgita Plisiene MD, Dirk Frechen MD, Felix Gramley MD, Patrick Schauerte MD

Department of Cardiology, RWTH Aachen University, 52074 Aachen, Germany

Received 8 November 2005; revised 14 December 2005 and 17 December 2005

TEE and Defibrillation

- Simple home made setup
- Readily available materials
- Designed and put together by the authors

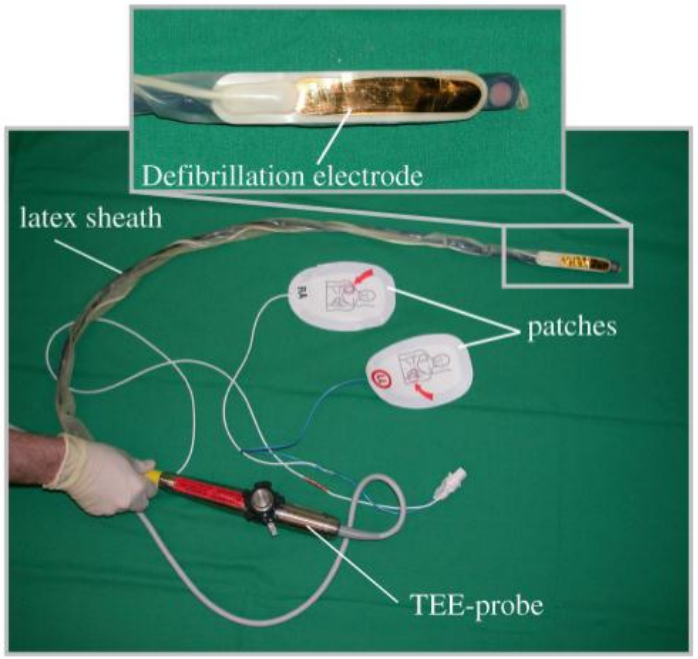


Fig. 1 Latex sheath with integrated defibrillation electrodes mounted on a conventional TEE probe.

TEE and Defibrillation

- Study subjects were pigs
- Very appropriate choice
- Not only possible but significant reduction in defibrillation thresholds noted
- The higher the body weight the larger the difference

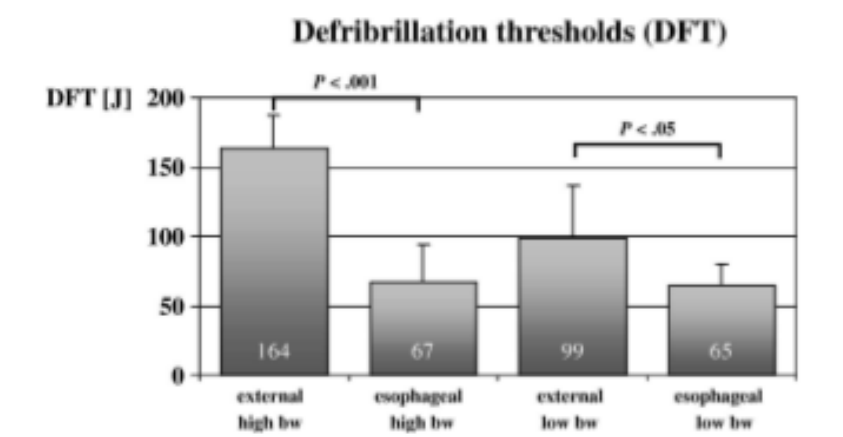


Fig. 3 Defibrillation thresholds for external and transesophageal defibrillation in pigs with high (n = 7) and low (n = 10) body weight. bw indicates body weight.

TEE and Defibrillation

- Other labs have also looked at this
- Successful trials
- Similar concepts

Journal of Accident and Emergency Medicine 1994 **11**, 139–143

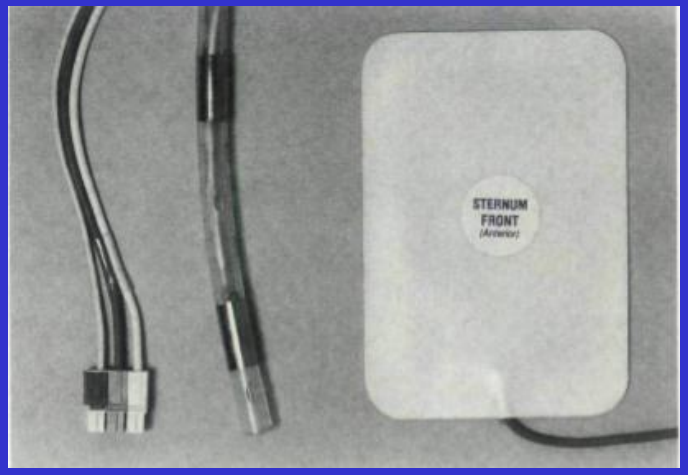
Mechanism of closed chest cardiopulmonary resuscitation investigated by transoesophageal echocardiography

A.C.H. PELL,[1] U.M. GULY,[2] G.R. SUTHERLAND,[1] D.J. STEEDMAN,[2] P. BLOOMFIELD[1] & C. ROBERTSON[2]

Departments of [1]Cardiology and [2]Accident and Emergency Medicine, Royal Infirmary, Lauriston Place, Edinburgh

SUMMARY

of practical importance in light of the realization that CPR is an imperfect method of sustaining the



TEE and Pacing

- Not well documented but one author group did stated they succeeded in pacing easily
- Low energy requirements
- How easy will it be to make a commercially available version?
- Not likely from a small start up company
- 510 K? Probably not
- Need to have wide range of medical device experience
- Any interest from manufacturers - Yes

So What Will This Give Us?

- Patient arrests
- Secure airway
- Place ETEE
- Leave in place and move off
- Can image heart rapidly
- Slow heart rate? No problem - pace
- V-fib? No problem – shock
- Couple this with external automated chest compression device…
- How about automated vascular access device?

Summary

- TEE offers numerous advantages
- No reason to toss out the TTE probe yet
- Need to push manufacturers to make smaller and less expensive probes
- Study use in Emergency/Critical Care settings
- Promising future for more capability