Received: January 2010; accepted: April 2010

CASE REPORT

Transoesophageal echocardiography allows bedside guidance of temporary pacing catheter placement A novel practical approach for the intensive care unit

DW Donker[1,2], EC Cheriex[2], EAC Bouman[1], E Pragt[1], DCJJ Bergmans[1]

1 Department of Intensive Care, Maastricht University Medical Center, Maastricht, The Netherlands
2 Department of Cardiology, Maastricht University Medical Center, Maastricht, The Netherlands

Abstract - Transoesophageal echocardiography (TEE) is increasingly used by intensivists as a bedside diagnostic tool for cardiac and haemodynamic assessment. We emphasize the versatility of TEE as an on-site imaging modality in the ICU by demonstrating TEE-guided positioning of a temporary transvenous pacing lead. The case of a haemodynamically unstable, mechanically ventilated patient who suffered a subacute inferior myocardial infarction complicated by interventricular septal rupture is presented. After surgical closure of the defect, the patient had an insufficient underlying rhythm and required urgent cardiac pacing due to failure of the standard temporary epicardial leads. Patient transfer to a fluoroscopy suite for conventional pacing catheter guidance was considered impossible due to the patient's instability. Alternatively, a temporary pacing catheter was introduced transvenously and appropriate positioning in the right ventricular cavity was guided by TEE. By this means, inadvertant lead-related perforation of the infarcted septum or free wall, manipulation of the patch or dislodgement of the pulmonary artery catheter could successfully be avoided. In order to confirm the accuracy of TEE-based visualization of a temporary pacing lead, we performed an in-vitro experiment: an echocardiographic view was generated by installing a TEE probe and pacing lead in a water bath demonstrating excellent differential visibility of the catheter, tip and electrodes.The available literature supports our experience and favours TEE as a rather fast, practical and accurate on-site imaging modality for right ventricular pacing lead placement in the ICU. This novel approach has to the best of our knowledge not been described before and could be incorporated in a goal-directed echocardiography training for non-cardiologist intensivists.

Keywords - **Focused echocardiography, transoesophageal echocardiography, transvenous temporary cardiac pacing, guidance of transvenous temporary pacing catheter, Intensive Care Unit**

Introduction

Transoesophageal echocardiography (TEE) is an imaging technique, for the assessment of cardiac function and haemodynamic monitoring in mechanically ventilated patients [1] which is gaining in popularity among intensivists. The bedside availability of echocardiography in the intensive care unit (ICU) renders this comprehensive cardiovascular imaging modality a versatile on-site tool.

Here, we describe an additional monitoring capability of TEE, i.e., bedside guidance of optimal positioning of a transvenously introduced temporary pacemaker lead.

Case

An 81-year-old female with a history of diabetes mellitus, hypertension and hypercholesterolaemia presented to the emergency department with a subacute inferior myocardial infarction complicated by cardiogenic shock.

Correspondence

DW Donker
E-mail: dirk.donker@mumc.nl

Immediate echocardiographic analysis revealed an infarction-related rupture of the interventricular septum (Figure 1 A). Subsequently, the patient underwent emergency coronary artery bypass grafting and operative closure of the septal defect using a patch.

Postoperatively, the patient was sedated and mechanically ventilated and remained haemodynamically unstable, requiring treatment with inotropes and intra-aortic counterpulsation. She was dependent on cardiac pacing via the temporary epicardial pacing leads, which were routinely applied peroperatively.

Her clinical course was further complicated by increasing atrial and ventricular pacing thresholds in the absence of an adequate underlying rhythm. A sustained and stable cardiac rhythm could not be achieved by administration of isoprenaline. Therefore, urgent transvenous temporary right ventricular pacing was considered.

Echocardiographic guidance of a temporary pacing lead

Multiplane TEE was performed using a compact ultrasound system at the bedside (X7-2t TEE probe, CX 50, Philips, Eindhoven, The Netherlands) and the right ventricular cavity was visualized (Figure 1 B).

A 4F temporary bipolar pacing catheter (Figure 1 and 2) (PACEL™, St. Jude Medical, Minnetonka, USA) was introduced transvenously via a sheath in the right internal jugular vein. An external pacemaker was connected to the pacing catheter and positioning of the lead was guided real-time by TEE, starting with a bicaval view and following the lead through right atrium, tricuspid valve and right ventricle using standard views. Adequate sensing and pacing thresholds were assured after an appropriate, stable position of the pacing catheter tip at the distal apical part of the interventricular septum was visualized (Figure 1 B). Using TEE, dislodgement of the pulmonary artery catheter and any manipulation of the patch applied to close the interventricular septal rupture or inadvertent perforation of the infarcted myocardial wall could successfully be avoided.

Table 1. Advantages of TEE to guide transvenous temporary pacing

Practical/ Convenient
- TEE is easily instituted in sedated and intubated ICU patients
- Staff trained in TEE are increasingly available in ICUs
- Views required for TEE are limited and can be taught to non-cardiologist intensivists as goal-directed, 'focused' echocardiography
Fast*
- On-site availability of ultrasound systems and TEE probes is increasing in ICUs
- Bedside availability of compact ultrasound systems
- Limited number of standard echocardiographic views sufficient for guidance
- No necessity for patient transfer to fluoroscopy facility
- TEE is suitable if immediate and successful pacing is required
- TEE is suitable when patient transfer is impossible due to clinical instability or recurrent bradycardia depending on patient positioning and manipulation
Accurate
- Ultrasound waves are reflected by pacing catheters and are differentially reflected by insulation and electrode materials at the catheter tip (Figure 1 B and 2)
- Intravascular/ intracardiac position of pacing catheter/ catheter tip can accurately be visualized
- TEE is suitable for guiding exact catheter positioning, e.g. if ventricular capture is difficult to achieve due to myocardial infarction
- TEE is suitable for guiding pacing catheter repositioning
Safe
- TEE itself is a relatively safe diagnostic procedure
- No radiation exposure for patient and operator as in fluoroscopy
- No procedural risks related to patient transfer
- Visualization of pacing catheter in relation to cardiac anatomical structures is relevant to prevent catheter-related complications

* Considered relatively fast in experienced hands comparable to transthoracic approaches if echocardiographic equipment is permanently on stand-by in the ICU including a ready-to-use TEE probe and a laryngoscope to facilitate introduction of the probe
TEE (transoesophageal echocardiography), ICU (Intensive Care Unit)

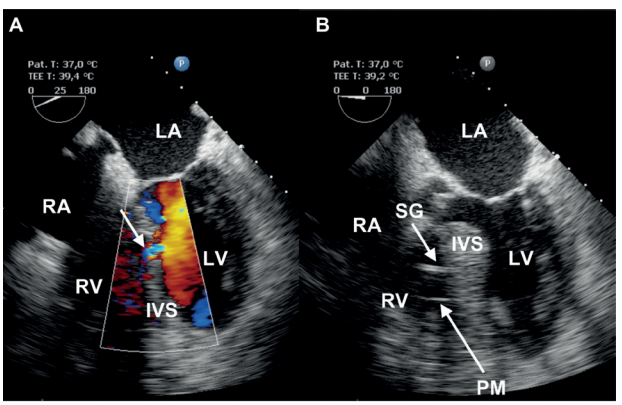
Discussion

TEE – a novel approach to guide temporary transvenous pacing

The elective or semi-elective introduction of a transvenous temporary pacing catheter is usually performed by a cardiologist and guided by fluoroscopy in a catheterization laboratory. However, this procedure requires the availability of experienced staff, a fluoroscopy facility and transportation of the patient. Importantly, patient transfer induces delay and carries considerable risks, particularly in mechanically ventilated, critically ill patients [2]. Moreover, an unstable clinical condition or the necessity of immediate cardiac pacing may prohibit any delay and patient transfer.

Alternatively, especially in an urgent situation, temporary pacing catheters can be introduced using a blind approach. Preferred introduction sites are the right internal jugular vein, the left subclavian vein or right supraventricular access to the right subclavian/ innominate vein [3,4]; while it should be remembered that an existing central venous line or sheath can possibly be exchanged, and also the pace port of a Swan-Ganz catheter already in situ can easily be used. This blind technique can be combined with electrocardiographic control of ventricular capture while pacing asynchronously [5]. In addition, 12-lead electrocardiography (ECG) can help to identify the lead position based on the ECG pattern of the paced ventricular complexes, e.g. in RV apex pacing: left bundle branch block configuration with positive complexes in lead I and negative complexes in lead III. Yet, catheter placement has been reported to have been unsuccessful in a considerable number of patients in an

Figure 1. TEE-guided visualization of temporary pacing catheter



(A) Interventricular septal rupture: Transoesophageal echocardiographic view of the right (RV), left (LV) ventricle, right (RA) and left (LA) atrium. The flow across the interventricular septal (IVS) rupture (arrow) is visualized by colour Doppler. (B) Same echocardiographic view as in (A). The temporary pacing catheter (PM) has a stable position in the RV cavity attached to the distal apical part of the interventricular septum (IVS). Note the more intense reflection of ultrasound waves at the tip of the pacing catheter (arrow indicates distal PM electrode) as compared to the more proximal part. SG (Swan-Ganz catheter) indicates the position of a pulmonary artery catheter.

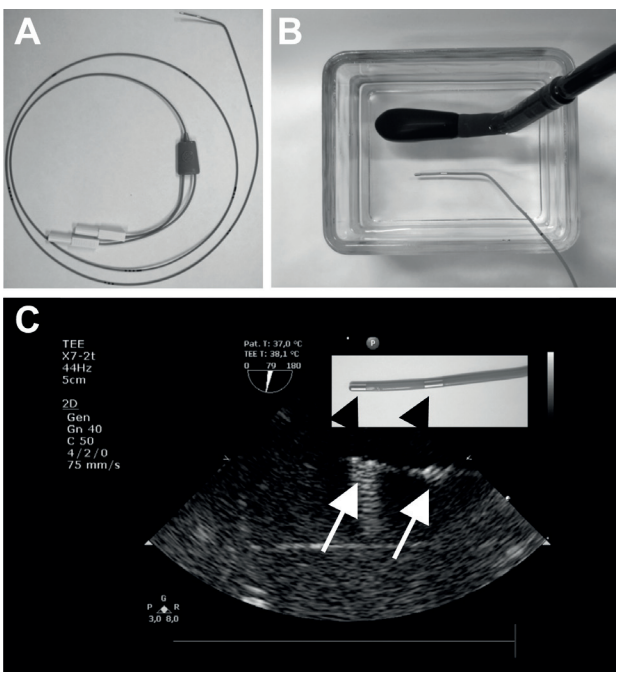
emergency setting, ranging between 30-97% [4,6]. In addition, complications such as lead misplacement, catheter loop formation, failure of capture and accidental perforation of the myocardium, are well known procedural pitfalls which could be prevented by an imaging-guided procedure [4,7].

In order to assist temporary pacing lead positioning, transthoracic echocardiography using a subcostal view in the supine position has been shown to be fast, safe and successful in patients requiring urgent pacing in an emergency situation [8-10]. Yet, transthoracic echocardiography may be hampered by anatomical constraints, i.e. large antero-posterior thoracic dimension, obesity, chronic pulmonary disease, supine position, mechanical ventilation, poststernotomy (subcostal drains, etc.), the latter three characteristics being of particular concern in patients admitted to an ICU.

The above-mentioned procedural drawbacks of transthoracic echocardiography are not applicable to TEE which is gaining increasing recognition as a bedside diagnostic tool in the intensive care unit, especially among non-cardiologists (Table 1). Therefore, the use of TEE should not simply be limited to complex cases; it is also indicated if proper visualization by TTE cannot be achieved. Others have reported successful TEE-guided placement of coronary sinus leads for permanent biventricular pacing as an alternative imaging technique to fluoroscopy [11,12]. To the best of our knowledge, this is the first report to describe the use of TEE as an on-site imaging tool to guide proper placement of a transvenous temporary pacing catheter.

In order to allow the intensivist to use echocardiography as an appropriate bedside imaging and monitoring tool, we suggest a practical approach to bradycardia in the ICU, as summarized in Table 2.

Figure 2. TEE in-vitro visualization of the bipolar pacing catheter



(A) The same standard 4F bipolar pacing catheter (PACELTM, St. Jude Medical, Minnetonka, USA) as used clinically (see Figure 1) is placed in a water bath (B) directly under a TEE probe (X7-2t, CX 50, Philips, Eindhoven, The Netherlands) in order to visualize the catheter (C). Note the more intense reflection of ultrasound waves at the distal and proximal pacing electrode (arrows) as compared to the insulated parts. For comparison, a detailed view (insert) of the bipolar catheter tip with an interelectrode spacing of 10 mm between the distal and the proximal electrode (arrowheads) is depicted.

Accuracy of localizing pacing leads using echocardiography

Echocardiography to visualize cardiac pacing wires has been described [13,14], although some experience of the technique is required to discriminate between the pacing leads, pulmonary artery catheters and anatomical structures. Moreover, echocardiography only provides a cross-sectional view of the catheter and visualization of the exact catheter position might be hampered by the fact that the curved catheter cannot be depicted in a single echocardiographic plane.

It is well known that ultrasound waves are reflected by pacing leads. Yet, we wondered if the insulation and electrode materials of the conventional bipolar pacing catheter that we used clinically would be differentially reflected, thereby allowing exact visualization of the catheter tip.

In order to confirm appropriate visualization of the pacing catheter we performed an in-vitro experiment. The catheter was placed in a water bath and its position was recorded with the same TEE probe we used clinically. It is evident from Figure 2 that the pacing electrodes which have an interelectrode space of 10mm reflect the ultrasound waves more prominently than the insulated parts of the catheter. In this way, the exact position of the catheter tip can be visualized and guided into a stable position within the right ventricular cavity until optimal thresholds are achieved.

Conclusion

TEE allows appropriate guidance of transvenous temporary pacing catheters at the bedside in the ICU. To the best of our knowledge this procedure has not previously been described. The available literature supports our personal experience that this procedure is practical, rather fast, accurate and safe. TEE guidance is particularly useful when immediate pacing is indicated and patient transfer to a fluoroscopy facility is considered impossible or carries considerable risks. Importantly, the procedure requires only a limited number of standard TEE views, which could be included in a goal-directed 'focused' TEE educational programme for non-cardiologist intensivists. Generally, the procedural advantages of echocardiography-based guidance of intravascular and intracardiac devices, e.g. temporary pacing lead, intra-aortic balloon pump, extracorporeal life support cannula, etc., are likely to have numerous practical implications for on-site therapy and monitoring in the ICU.

Table 2. Practical approach to bradycardia* in the ICU

Presence of temporary pacing lead(s)+
- Connect external pacemaker to temporary atrial/ ventricular lead(s)
- Consider immediate initiation of "emergency pacing mode"#
- If non-capture, consider steps described in **"Absence of temporary pacing lead(s)"**
- Check
• external pacemaker switched "on"
• battery pack status "OK"
• proper connection of all electrical cables, connectors and plugs (NB: atrial leads connected to ventricular pacemaker port and vice versa)
• appropriate pacing mode programmed
• cathodal and anodal pacing possibilities
• maximum increase of pacing pulse width
• pacing via an additional subcutaneous lead$
• correct (transvenous) lead position: TTE, TEE, 12-lead ECG, chest X-ray
- If successful atrial/ ventricular pacing is established, consider determining sensing and pacing thresholds**
- Search for underlying pathology to explain bradycardia*, e.g. ischaemia, electrolyte abnormalities, medication, pre-existing information (history, ECG) on abnormalities of impulse formation or conduction, etc.
- Consider surgical/ interventional (re-)implantation/ revision of temporary pacing lead(s), see also **"Absence of temporary pacing lead(s)"** for decision making
Absence of temporary pacing lead(s)+
- If possible, register abnormalities of impulse formation and/ or conduction on ECG
- Consider atropine (especially in sinus bradycardia and proximal atrio-ventricular block)
- Consider isoprenaline (especially in distal, infra-His block)
- Consider surgical/ interventional implantation/ introduction of temporary pacing lead(s)
• implantation of (new) epicardial leads after cardiac surgery
• interventional strategy:
- "blind approach" or via pace port of Swan-Ganz catheter, justified in urgent situations, consider postprocedural verification of lead position by 12-lead ECG, chest X-ray, fluoroscopy, TTE or TEE (see text for details)
- if possible, transfer to fluoroscopy facility to guide lead placement***
- if transfer impossible, guide lead placement by TTE or TEE****

* Haemodynamically significant or symptomatic due to abnormalities of impulse formation and/ or conduction

\+ Temporary epicardial or transvenous endocardial atrial and/ or ventricular lead(s)

\# Availability of "emergency pacing mode" depends on external pacemaker model; alternatively, start asynchronous pacing (DOO, VOO, AOO mode) with maximum output, minimum sense

$ A subcutaneous lead can easily be inserted, preferentially in the precordial area, and used as alternative lead

** Remember that determination of sensing thresholds should ideally be performed before initiation of pacing, yet requires an adequate underlying rhythm

*** Depending on urgency, availability and experience of operator (cardiologist, intensivist)

**** Depending on urgency, availability and experience of operator (cardiologist, intensivist); TTE is preferred to TEE if adequate imaging is possible by TTE

ECG (electrocardiogram), TTE (transthoracic echocardiography), TEE (transoesophageal echocardiography), ICU (Intensive Care Unit)

References

1. Poelaert J. Use of ultrasound in the ICU. Best Pract Res Clin Anaesthesiol 2009;23:249-261.

2. Beckmann U, Gillies DM, Berenholtz SM, Wu AW, and Pronovost P. Incidents relating to the intra-hospital transfer of critically ill patients. An analysis of the reports submitted to the Australian Incident Monitoring Study in Intensive Care. Intensive Care Med 2004;30:1579-1585.

3. Harrigan RA, Chan TC, Moonblatt S, Vilke GM, and Ufberg JW. Temporary transvenous pacemaker placement in the Emergency Department. J Emerg Med 2007;32:105-111.

4. Birkhahn RH, Gaeta TJ, Tloczkowski J, Mundy T, Sharma M, Bove J, et al. Emergency medicine-trained physicians are proficient in the insertion of transvenous pacemakers. Ann Emerg Med 2004;43:469-474.

5. Bartecchi CE. Bedside emergency transvenous cardiac pacing: experience in two community hospitals. Jacep 1976;5:169-173.

6. Syverud SA, Dalsey WC, and Hedges JR. Transcutaneous and transvenous cardiac pacing for early bradyasystolic cardiac arrest. Ann Emerg Med 1986;15:121-124.

7. Cooper JPSwanton RH. Complications of transvenous temporary pacemaker insertion. Br J Hosp Med 1995;53:155-161.

8. Pinneri F, Mazza A, Garzaro L, Galeazzi M, De Felice F, Russo M, et al. [Temporary emergency cardiac pacing under continuous echocardiographic control. Feasibility and safety of the procedure without using fluoroscopy]. Ital Heart J Suppl 2003;4:581-586.

9. Macedo W, Jr., Sturmann K, Kim JM, and Kang J. Ultrasonographic guidance of transvenous pacemaker insertion in the emergency department: a report of three cases. J Emerg Med 1999;17:491-496.

10. Aguilera PA, Durham BA, and Riley DA. Emergency transvenous cardiac pacing placement using ultrasound guidance. Ann Emerg Med 2000;36:224-227.

11. Plotkin IM, Collard CD, Aranki SF, Rizzo RJ, and Shernan SK. Percutaneous coronary sinus cannulation guided by transesophageal echocardiography. Ann Thorac Surg 1998;66:2085-2087.

12. Artrip JH, Sukerman D, Dickstein ML, and Spotnitz HM. Transesophageal echocardiography guided placement of a coronary sinus pacing lead. Ann Thorac Surg 2002;74:1254-1256.

13. Nanda NC, Barold SS. Usefulness of echocardiography in cardiac pacing. Pacing Clin Electrophysiol 1982;5:222-237.

14. Drinkovic N. Subcostal echocardiography to determine right ventricular pacing catheter position and control advancement of electrode catheters in intracardiac electrophysiologic studies. M mode and two dimensional studies. Am J Cardiol 1981;47:1260-1265.