CASE REPORT

Transesophageal Echocardiography During Cardiac Arrest in Orthopedic Surgery Patients: A Report of Two Cases and a Review of the Literature

Sean Garvin, MD · Ottokar Stundner, MD · Stavros G. Memtsoudis, MD, PhD, FCCP

Received: 3 January 2013/Accepted: 27 March 2013 / Published online: 10 July 2013
© Hospital for Special Surgery 2013

Abstract *Background:* Cardiac arrest situations represent an enormous clinical challenge to the physicians involved. Research suggests that the utilization on transesophageal echocardiography (TEE) may provide important diagnostic information and allows for institution of more specific treatment, while not hampering resuscitation efforts. *Case Description:* In this review, we highlight the usefulness of TEE in cardiac arrest situations in the orthopedic setting, by presenting two perioperative cases. In one case, TEE was used to diagnose intraoperative pulmonary embolism and guide thrombolytic therapy. The second case highlights the use of TEE in management of hemodynamic instability in a patient with aortic stenosis. *Literature Review:* Memtsoudis et al. showed that in 19 of 22 cardiac arrests, an underlying pathological process could be established with TEE, leading to specific interventions beyond the institution of advanced cardiac life support measures. *Clinical Relevance:* TEE can provide rapid diagnostic information guiding treatment in patients with hemodynamic compromise. The use is expanding beyond the cardiac operating theater and given the potential clinical impact consideration should be given to utilizing this valuable imaging modality in appropriate clinical situation.

Electronic supplementary material The online version of this article (doi:10.1007/s11420-013-9331-2) contains supplementary material, which is available to authorized users.

Work performed at: Department of Anesthesiology, Hospital for Special Surgery, Weill Medical College of Cornell University.

S. Garvin, MD · O. Stundner, MD ·
S. G. Memtsoudis, MD, PhD, FCCP (✉)
Department of Anesthesiology,
Hospital for Special Surgery,
535 East 70th Street, New York, NY 10021, USA
e-mail: MemtsoudisS@hss.edu

S. Garvin, MD · O. Stundner, MD ·
S. G. Memtsoudis, MD, PhD, FCCP
Weill Medical College of Cornell University, New York, NY 10065,
USA

Keywords transesophageal echocardiography · cardiac arrest · orthopedic surgery · cardiac complications · embolism · resuscitation

Introduction

Cardiac arrest represents an enormous clinical challenge to the physicians involved. Unfortunately, the causes leading to cardiopulmonary collapse are often elusive. As a result, the arrest team operating under time pressure must rely on the generic, non-specific Advanced Cardiac Life Support (ACLS) Protocols [2]. The prospect of accurately diagnosing the underlying cause for the arrest may allow clinicians to more selectively treat the patient's condition and increase the chances of a successful resuscitation. Recent research suggests that the utilization of transesophageal echocardiography (TEE) may provide important diagnostic information and allow for institution of more specific interventions, while not hampering resuscitation efforts [4].

Memtsoudis et al. showed that in 19 of 22 cardiac arrests, an underlying pathological process could be established with TEE, leading to specific interventions beyond the institution of ACLS measures [8]. In this series, thromboembolic phenomena made up 50% of diagnoses. Pulmonary embolism has been identified as the most important complication associated with perioperative cardiopulmonary arrest after total joint arthroplasty and found to increase the odds of a fatal outcome 40-fold [7]. TEE may, therefore, represent a valuable tool during cardiac arrest in the orthopedic patient population. This is especially important as targeted pharmacological interventions are available that can be implemented at the patient's bedside in the form of potent thrombolytic agents [10]. Moreover, the value of TEE is not limited to the diagnosis of embolic events and extends to detection of valvular abnormalities, acute myocardial compromise, pericardial tamponade, and other life-threatening conditions. In this article, we highlight the usefulness of TEE in cardiac arrest situations in the orthopedic setting

by presenting two perioperative cases. In both cases, a diagnosis was made by echocardiography that guided specific management. Our goal is to heighten awareness regarding the utility of TEE among members of the orthopedic community by the addition of our experience to the medical literature and promote its use whenever possible during a cardiac arrest.

Case Reports

Case 1

A 70-year-old female with history of hypertension and osteoarthritis was admitted for primary right total knee arthroplasty. Preoperative evaluation was notable for limited exercise tolerance predominantly due to knee pain. A preoperative chest radiograph demonstrated no active disease and an EKG revealed normal sinus rhythm with left ventricular hypertrophy. Laboratory studies were unremarkable. She denied any past surgical history, alcohol or illicit drug use.

Prior to induction of anesthesia the patient's vital signs revealed a blood pressure of 140/84 mmHg, a heart rate 99 bpm, and an oxygen saturation of 98% on room air. Shortly after anesthesia induction that included a femoral nerve block and combined spinal–epidural anesthetic performed with 10 mg of 0.5% Bupivacaine injected intrathecally, the patient developed hemodynamic collapse that was manifested by pulseless electrical activity. ACLS protocol was initiated, the trachea was intubated and invasive monitors placed. While CPR was ongoing, a TEE examination was performed that showed an akinetic severely dilated right ventricle, and a small underfilled hypercontractile left ventricle. Examination of the main and proximal branch pulmonary arteries revealed absence of color flow Doppler in proximal right pulmonary artery with extension of flow disturbance into the main pulmonary artery, consistent with pulmonary embolism. As a result of the echocardiogram findings, tissue plasminogen activator was administered with subsequent restoration of a perfusing rhythm. The echocardiogram demonstrated improvement in flow in the proximal pulmonary arteries with severe hypokinesis of the right ventricle. Unfortunately, upon reperfusion of the pulmonary circulation, the patient developed severe pulmonary edema. In spite of interventions to support myocardial contractility including administration of epinephrine and milrinone, vasopressor support with high-dose vasopressin and additional efforts to lower pulmonary artery pressure including administration of nitroglycerin, correction of acidosis, and hyperventilation the patient expired soon thereafter.

Case 2

An 85-year-old male with history of atrial fibrillation, hypertension, gastroesophageal reflux, diabetes mellitus type 2, and benign prostate hypertrophy underwent uncomplicated total knee arthroplasty. Previous surgical history included uncomplicated contralateral total knee replacement and a cholecystectomy. A preoperative stress test revealed mild apical, reversible ischemia. An echocardiogram 1 year prior showed mild to moderate aortic stenosis with an ejection fraction of 48% and

no other abnormalities. His EKG was consistent with normal sinus rhythm with first degree AV block. On review of systems, the patient denied any chest pain, dyspnea on exertion, palpitations, or syncope. As the patient was asymptomatic from a cardiopulmonary perspective, the surgery proceeded as planned. His vital signs before surgery were a blood pressure of 150/90 mmHg, a heart rate of 96 bpm with an oxygen saturation of 96% on room air. He underwent knee arthroplasty without complications under combined spinal–epidural anesthesia and a femoral nerve block. Postoperatively, he was observed in a monitored setting and was ruled out for myocardial infarction given his positive stress test and discharged to the floor on postoperative day 1. Postoperatively, his hospital discharge was delayed as his INR rose above 3.5 in response to warfarin therapy and because he experienced some difficulty achieving physical therapy milestones. On postoperative day 9, he collapsed while performing physical activities and was found to be unresponsive and pulseless. ACLS protocol was immediately instituted and the patient's trachea was intubated. EKG tracings were consistent with pulseless electrical activity. The patient was given intravenous epinephrine and chest compressions were instituted with eventual return of perfusion. An arterial line was inserted and an epinephrine and phenylephrine infusion started to support the patient's hemodynamics. A TEE was performed that revealed severe hypovolemia characterized by near complete left ventricular cavity obliteration during systole in the transgastric left ventricular short axis view, global mild to moderate hypokinesis and a heavily calcified trileaflet aortic valve with minimal leaflet excursion during systole with a valve area estimated by planimetry of 0.7 cm² in the mid-esophageal aortic valve short axis view, consistent with severe aortic stenosis. In response, the patient was rapidly given 2.5 l of lactated ringers and the vasopressor infusions were weaned off over the next 20 min as the patient stabilized.

The patient was transferred to the cardiac critical care unit for monitoring and evaluation. After cardiology assessment, coronary artery catheterization, and confirmatory repeat echocardiography, the patient was referred for aortic valve replacement during the same hospitalization, which was performed 3 days after the cardiac arrest. The patient recovered well from both operations and was eventually discharged without neurologic sequelae.

Discussion

Here, we have presented two cases in which the emergent use of transesophageal echocardiography impacted clinical decision making in orthopedic surgery patients. This report highlights the fact that the spectrum of cardiac abnormalities contributing to perioperative morbidity and mortality in orthopedic surgery patients includes thromboembolic disease, coronary artery disease, and complex valvular heart disease.

Thromboembolism during the perioperative period in patients undergoing arthroplasty is a leading cause of morbidity and mortality [7]. Echocardiography has been used to diagnose and manage embolic complications in orthopedic surgery patients [1, 8, 12] and may have a high clinical impact intraoperatively [4, 8] and during cardiac arrest [4]. In case 1, TEE

documented a massive pulmonary embolism causing cardiac arrest that occurred after the induction of anesthesia, prior to the start of surgery which is in contrast to earlier reports, likely indicating the presence of in situ venous thrombus prior to arrival to the operating room. In most instances associated with TKR, the embolic event occurs intraoperatively after tourniquet deflation [3, 9], or in the early postoperative period. In this case, the TEE allowed for a quick diagnosis and guided the administration of thrombolytics which temporarily restored a perfusing rhythm.

Case 2 represents a clinical challenge for those caring for patients with severe valvular heart disease. The patient's preoperative echocardiogram was performed a year prior to surgery and given the variability in progression of aortic stenosis [11], the degree of aortic stenosis likely had been underestimated in the preoperative evaluation, thereby predisposing the patient to the postoperative events described. Syncope, hypotension, and arrhythmia from hypovolemia are all common in patients with severe aortic stenosis and thus the availability of TEE for diagnosis of this abnormality to guide life-saving therapy cannot be underestimated [15]. One observational study of a random population of elderly, aged greater than 65, suggested that up to 9% of this population have some degree of aortic stenosis, with critical aortic stenosis found in 2.2% [5]. An additional prospective outcome study, found that asymptomatic patients with mild to moderate aortic stenosis had an event-free survival defined as death or aortic valve surgery of 95 ± 2 , 75 ± 3 , and $60 \pm 5\%$ at 1, 3, and 5 years and concluded that outcome is worse in this population than previous data has suggested [11]. The identification of severe valvular heart disease contributing to cardiac arrest represents an additional diagnostic consideration that cannot be overlooked.

Perioperative transesophageal echocardiography has broadened its application beyond the cardiac surgical population, with mounting evidence of benefit to patients undergoing noncardiac surgery [6]. Specifically, TEE may be useful in diagnosing and managing patients with cardiovascular collapse, hypovolemia, coronary ischemia, pericardial diseases, and complex valvular heart disease [14]. The National Board of Echocardiography recognizing the impact that TEE can have in the perioperative management of patients has established two levels of certification for anesthesiologists. The first certifies anesthesiologists in performance of basic TEE when used as a monitoring tool. A second, advanced certification for diagnostic examination is also issued, but requires additional fellowship training in cardiovascular disease [13].

As the orthopedic surgery population continues to age, we will see increasing numbers of patients with multiple risk factors and complex cardiac disease. In this report, we illustrate how TEE can contribute to clinical decision making during acute resuscitation in the orthopedic surgery setting. In both cases, a diagnosis was made that guided specific management. The addition of TEE capabilities to in hospital cardiac arrest teams will require investment in equipment and significant training of staff, but will add potentially life-saving benefits to critically ill patients. We hope that this review increases awareness regarding the utility of TEE among members of the orthopedic surgery community and promotes its use whenever the appropriate situation arises.

Disclosures

Conflict of Interest: Sean Garvin, MD, Ottokar Stundner, MD, Stavros G Memsoudis, MD, PhD, FCCP have declared that they have no conflict of interest.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Informed Consent: Informed consent was waived from all patients for being included in the study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

References

1. Canty DJ, Royse CF. Audit of anaesthetist-performed echocardiography on perioperative management decisions for non-cardiac surgery. *Br J Anaesth*. 2009;103:352-8.
2. Field JM, Hazinski MF, Sayre MR, et al. Part 1: Executive summary: 2010 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation*. 2010;122:S640-56.
3. Hirota K, Hashimoto H, Tsubo T, Ishihara H, Matsuki A. Quantification and comparison of pulmonary emboli formation after pneumatic tourniquet release in patients undergoing reconstruction of anterior cruciate ligament and total knee arthroplasty. *Anesth Analg*. 2002;94:1633, 8, Table of Contents.
4. Lin T, Chen Y, Lu C, Wang M. Use of transoesophageal echocardiography during cardiac arrest in patients undergoing elective non-cardiac surgery. *Br J Anaesth*. 2006;96:167-70.
5. Lindroos M, Kupari M, Heikkilä J, Tilvis R. Prevalence of aortic valve abnormalities in the elderly: an echocardiographic study of a random population sample. *J Am Coll Cardiol*. 1993;21:1220-5.
6. Mahmood F, Christie A, Matyal R. Transesophageal echocardiography and noncardiac surgery. *Semin Cardiothorac Vasc Anesth*. 2008;12:265-89.
7. Memsoudis SG, Della Valle AG, Besculides MC, Esposito M, Koulouvaris P, Salvati EA. Risk factors for perioperative mortality after lower extremity arthroplasty: a population-based study of 6,901,324 patient discharges. *J Arthroplasty*. 2010;25:19-26.
8. Memsoudis SG, Rosenberger P, Löffler M, et al. The usefulness of transesophageal echocardiography during intraoperative cardiac arrest in noncardiac surgery. *Anesth Analg*. 2006;102:1653-7.
9. Parmet JL, Berman AT, Horrow JC, Harding S, Rosenberg H. Thromboembolism coincident with tourniquet deflation during total knee arthroplasty. *Lancet*. 1993;341:1057-8.
10. Rahimtoola A, Bergin JD. Acute pulmonary embolism: an update on diagnosis and management. *Curr Probl Cardiol*. 2005;30:61-114.
11. Rosenhek R, Klaar U, Schemper M, et al. Mild and moderate aortic stenosis. Natural history and risk stratification by echocardiography. *Eur Heart J*. 2004;25:199-205.
12. Shine TS, Feinglass NG, Leone BJ, Murray PM. Transesophageal echocardiography for detection of propagating, massive emboli during prosthetic hip fracture surgery. *Iowa Orthop J*. 2010;30:211-4.
13. Shook DC. Basic perioperative transesophageal echocardiography: an education opportunity and a dilemma. *J Am Soc Echocardiogr*. 2010;23:34A. 34A.e1.
14. Suriani RJ, Neustein S, Shore-Lesserson L, Konstadt S. Intraoperative transesophageal echocardiography during noncardiac surgery. *J Cardiothorac Vasc Anesth*. 1998;12:274-80.
15. Torsher LC, Shub C, Rettke SR, Brown DL. Risk of patients with severe aortic stenosis undergoing noncardiac surgery. *Am J Cardiol*. 1998;81:448-52.