

The Development of a Perioperative Echocardiography Consult Service: The Nebraska Experience

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THE EXPANSION OF PERIOPERATIVE ultrasound has broadened the scope of practice of perioperative physicians to include the use of rescue echocardiography, echocardiography in noncardiac surgery, and echocardiography in critical care medicine.^{1,2} Anesthesiologists proficient in echocardiography find themselves using the skill outside of the cardiac operating room, and the demands for clinical expertise in both transesophageal and transthoracic echocardiography rapidly are growing.^{3,4} As anesthesiologists' involvement in perioperative care continues to expand, so does the challenge to advance perioperative ultrasound.^{5,6} The purpose of this paper is to describe the experience of an academic medical center in training, building, and implementing a perioperative echocardiography consult service. The educational processes, development of the clinical service, procurement of institutional support, and quality management of a perioperative echocardiography service will be described.

BUILDING A "CRITICAL MASS" OF EXPERTS

The Nebraska Medical Center Hospital on the University of Nebraska Medical Center (UNMC) campus is a tertiary care hospital with 627 patient beds and approximately 16,000 operations annually. The Department of Anesthesiology's staff of 35.3 full-time employee (FTE) faculty anesthesiologists, 28.1 FTE-certified registered nurse anesthetists, and 53 FTE resident and fellow physicians perform approximately 23,000 anesthetics annually (calendar year 2013). In 2008, the Department of Anesthesiology had one cardiac anesthesiologist with certification in advanced perioperative transesophageal echocardiography (TEE) supporting two cardiac surgeons who performed approximately 340 cardiac surgeries per year. Institutional growth of cardiothoracic surgical services led the department to identify four cardiac anesthesiology faculty to undergo an executive fellowship in perioperative and critical care echocardiography through the University of Utah Medical Center Departments of Anesthesiology and Cardiology from 2008 to 2009. The year-long program required four weeks on-site and 200 required peer-reviewed TEE exams and transthoracic echocardiography (TTE) exams along with web-based material to be completed. The program focused on both TTE and TEE, and required passing the Examination of Special Competence in Advanced Perioperative Transesophageal Echocardiography (advanced PTEeXAM) for course completion.⁷ The total cost to the department to train these four individuals was broken down into tuition (\$40,000/faculty), travel/lodging (\$1,605/week), cost of the days out of clinical service (\$1,800/day/faculty), and the cost of the advanced PTEeXAM (\$995/examinee).⁷ Total costs in 2009 to the department to train and test four faculty in advanced echocardiography came to \$333,660 (Table 1). These individuals subsequently all

received certification in Advanced Perioperative Transesophageal Echocardiography through the National Board of Echocardiography. Three of the physicians trained in advanced echocardiography also passed the Examination of Special Competence in Adult Echocardiography (ASCeXAM), a board examination that covers advanced transthoracic echocardiography techniques and topics.⁷

Increasing the Number of Advanced-Trained Physicians

From 2010 to 2012, members of the "critical mass" of echo-competent individuals formally trained six more UNMC faculty (four cardiac anesthesiologists, two transplant anesthesiologists) in advanced perioperative echocardiography using an on-site internal training program developed by the UNMC Department of Anesthesiology. The program included four weeks (8 hours/day) of didactics over the year-long course, online graded echo examinations with required interpretation, 40 hours of hands-on live model TTE scanning, TEE simulation training, and case reviews. The additional faculty completed the program and took the advanced PTEeXAM.⁷ The total cost of training these individuals, including tuition (\$20,000/faculty), cost of the days out of clinical service (\$1800/day/faculty), and examination fees (\$995/examinee), incurred by the Department of Anesthesiology totaled \$341,970 (see Table 1). By 2013, a total of 10 faculty (eight cardiac anesthesiologists, two transplant anesthesiologists) had formal training in advanced perioperative echocardiography. The training of these individuals allowed the department to have a core group of advanced trained faculty for 100% of cardiac cases, with the long-term goal of using TEE in all liver transplant cases.

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Table 1. Cost of Perioperative Echocardiography Education to the Department of Anesthesiology at the University of Nebraska Medical Center

Yr	Tuition Cost	Travel Cost	Exam Costs	Cost of Days out of OR	Total Cost to Dept
2008-2009	\$160,000	\$25,680	\$3,980	\$144,000	\$333,660
4 Faculty Advanced Training					
2010-2012	\$120,000	NA	\$5,970	\$216,000	\$341,970
6 Faculty Advanced Training					
2013	\$17,500	NA	NA	\$75,600	\$93,100
7 Faculty Basic Training					
<i>Total Cost of Training 17 Faculty in Perioperative Echo from 2008-2013:</i>					<i>\$768,730</i>

Abbreviation: Dept, department; NA, not applicable; OR, operating room.

Increasing the Number of Basic-Trained Physicians

By 2013, in response to requests by both surgical and perioperative physicians, the authors recognized the need to expand echocardiography services to include liver transplantation, critical care medicine, acute care and trauma surgery, preoperative screening and evaluation, and the postanesthesia care unit.^{8,9} Concurrently, the department acknowledged the need for additional training options for physicians already in practice in basic TTE and TEE. Thus, the department developed a year-long basic perioperative echocardiography training program, focused on both TEE and TTE. Similar to the advanced echocardiography training program, the basic perioperative echocardiography training program was developed for physicians across subspecialties. This program required completion of 100 echocardiography examinations peer-reviewed by a certified instructor. Fifty of the exams were performed, interpreted, and reported by the trainee; an additional 50 exams were to be interpreted by the student and reviewed with a certified instructor. The six-day on-site curriculum employed didactics, echocardiography simulation, and live-model scanning. All course web-based materials and examinations were required to be completed over one year. The authors first trained their own faculty; seven noncardiac faculty completed the training (four specializing in transplant and three in critical care anesthesiology). The total cost for the education of these seven faculty trained in basic echocardiography including tuition (\$2,500/faculty) and cost of the days out of clinical service (\$1,800/day/faculty) equaled \$93,100, as described in Table 1.

Completing the "Critical Mass"

As a result of the above educational initiative, in June 2014, a total of 17 faculty within the Department of Anesthesiology have received formalized training in either basic or advanced perioperative echocardiography. Nine faculty members gained testamur status in advanced PTEeXAM, with 5 faculty having certification in advanced perioperative transesophageal echocardiography. Four faculty are in the certification process, and

seven faculty have plans to take the next basic perioperative transesophageal examination. In 6 years, the number of anesthesiologists within the Department of Anesthesiology with formal training in echocardiography increased in number from 1 to 17, resulting in nearly half ($n = 17/35.3$, 48%) of full-time faculty within the department having either advanced or basic echocardiography skills (Table 2).

SECURING EQUIPMENT AND SPACE

In 2008, the Department of Anesthesiology owned one Vividi portable ultrasound machine and one TEE probe (6T) (General Electric Healthcare, Fairfield, CT). Two larger systems, Philips HP5500 (Philips Healthcare, Andover, MA), were borrowed from the echocardiography laboratory at The Nebraska Medical Center (TNMC) and used in the cardiac operating rooms. As more faculty underwent training, clinical utilization of the portable unit increased exponentially. In 2009, in collaboration with the Section of Cardiology and the Medical Director of the Echocardiography Laboratory, the Department of Anesthesiology led an initiative to purchase a total of four Philips CX50 portable ultrasound machines, four X7-2t 3D xMATRIX array TEE probes, one S7-3t pediatric TEE probe, and 4 TTE probes (S5-1) (Philips Healthcare, Andover, MA). The equipment was purchased through the Perioperative Services cost center at TNMC and not by the department.

In 2012, expansion of cardiac services led to the purchase of a Philips iE33 ultrasound system, another TEE probe, two more TTE probes with 3D capabilities, as well as two advanced 3D echo quantification packages for off-line analysis. Because of increased utilization of 3D TEE, in 2013 an additional iE33 ultrasound system and TEE probe (X7-2t, 3D xMATRIX array) were transferred to Perioperative Services from the Echocardiography Laboratory at TNMC. Total equipment expenditures for six total ultrasound systems, seven TEE probes, and six surface probes from 2009-2013 equaled \$531,421, with an annual equipment expenditure of \$106,284. The annual cost of equipment repair and service agreements is approximately \$8,760 per year.

Table 2. UNMC Anesthesiologists Completing Formal Perioperative Echocardiography Training

Yr Training Completed	Number of Faculty Completing Basic Perioperative Echocardiography Training	Number of Faculty Completing Advanced Perioperative Echocardiography Training
2009		4
2010		
2011		4
2012	4	2
2013	3	
<i>Number of Echo Faculty:</i>	<i>7 (4 transplant, 3 critical care anesthesiologists)</i>	<i>10 (8 cardiac, 2 transplant anesthesiologists)</i>
<i>Faculty with Advanced PTE certification as of 2014:</i>		5
<i>Faculty with Advanced PTE testamur status as of 2014:</i>		4

Abbreviation: PTE, perioperative transesophageal echocardiography.

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