

## Original Article

## Perioperative Point-of-Care Ultrasound Training: A Survey of Anesthesia Academic Programs in United States and China

Jeffrey Cannon<sup>1</sup>, Daniel C. Sizemore<sup>2</sup>, Yang Zhou<sup>3</sup>, George M. McKelvey<sup>4</sup>, Min Li<sup>3</sup>,  
Elie J. Chidiac<sup>5</sup>, Xiangyang Guo<sup>3</sup>, Alexandra Reynolds<sup>2</sup>, and Hong Wang<sup>2</sup>

## ABSTRACT

**Background:** Ultrasound plays a large role in daily anesthesia practice and training in the 21st century. From obtaining vascular access to performing a transesophageal echocardiography (TEE), anesthesiologists are expanding their use of ultrasound. Point-of-Care ultrasound (POCUS) is using bedside ultrasound machines to rapidly evaluate, diagnose, and guide patient care, without delay. Multiple residency specialty programs are beginning to implement POCUS training in several clinical situations. However, the current status of POCUS training in Anesthesia residency is unknown.

**Methods:** A 22-question online survey was sent to US Accreditation Council for Graduate Medical Education (ACGME) Programs and Chinese Programs (Academic hospital setting with an associated residency program in anesthesiology). The survey questions gauged current levels of training and exposure to ultrasound training in several areas such as clinical, didactic, and conferences. Survey enquiries included specialized areas of ultrasound training including regional blocks, TEE, and POCUS. Survey questions also gauged the extent to which POC teaching occurred in institutional curriculums or at regional/national meetings.

**Results:** There were 130 survey responses from US ACGME anesthesia residency programs and 394 responses from Chinese Anesthesia Residency facilities. US survey responses comprised of 48.5% responses from residents and 51.5% of responses from faculty. Chinese survey responses comprised of 27% responses from residents and 72% responses from either attendings, vice chiefs, or chief physicians. Both countries exhibited a high level of ultrasound-guided regional block training with 96.2% in the US and 94% in China. The extent of TEE training is also universally high in the US with 87.7% of US respondents having received training. TEE training in China was observed to be integrated into cardiac anesthesia rotations. In the US, only 36.2% of survey respondents had received POCUS training, with even fewer (10%) receiving POCUS rotations. In both US and Chinese surveys, less than half of respondents (43.9% in the US vs. 39.9% in China) had attended a POCUS workshop.

**Conclusion:** A little over one third (36.2%) of US respondents received explicit POCUS training and even fewer (10%) received specific POCUS rotations during their anesthesia residencies. In China, POCUS training only exists in 24.4% of programs, and POCUS rotations are even less available (12.2%). Given the importance of POCUS's evolving role in anesthesiology, these survey responses show that while there is awareness of POCUS, there is insufficient POCUS training during anesthesia residency in both US and Chinese academic training programs.

From the <sup>1</sup>School of Medicine, <sup>2</sup>Department of Anesthesiology, West Virginia University, Morgantown, WV, USA; <sup>3</sup>Department of Anesthesiology, Peking University Third Hospital, Beijing, China; <sup>4</sup>Department of Anesthesiology, Detroit Medical Center, <sup>5</sup>Department of Anesthesiology, Wayne State University, Detroit, MI, USA.

**Correspondence** to Dr. Hong Wang at [hong.wang1@wvumedicine.org](mailto:hong.wang1@wvumedicine.org).

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Ultrasound holds a wealth of clinical utility for all specialties. No longer a tool of radiologists only, ultrasound is heavily utilized by emergency medicine, cardiology, and many other healthcare specialties. Point-of-Care Ultrasound (POCUS) has emerged as a new, promising clinical modality for providing bedside examinations without having to take the patient to a specific ultrasound designated suite. POCUS has been used extensively in emergency and intensive care medicine to enable clinical scenarios such as quick evaluation of an airway, diagnosing pericardial effusion, and finding intussusception (1, 2). POCUS has become part of Advanced Trauma Life Support (ATLS) and has been suggested by critical care medicine to be included in the perioperative cardiopulmonary resuscitation (3). The basic knowledge of ultrasound has been recently introduced into medical school curricula with many US schools integrating ultrasound training into their curricula through first-year anatomy classes, second-year pathology class, third-year clerkships, and clinical skills training throughout (4).

The Accreditation Council for Graduate Medical Education (ACGME) has detailed requirements of POCUS training in Emergency Medicine Residency and Critical Care Fellowship programs. It is one of the key procedures for emergency medicine residents who must perform at least 150 bedside ultrasound exams (5). For Critical Care Fellowship programs, POCUS is clearly defined as one of the required milestones (6). Many anesthesiology resident training program curriculums include ultrasound-guided regional block and transesophageal echocardiograph rotations, however, few programs provide specific POCUS training curriculums and rotations.

Although some concepts of POCUS training are included in the anesthesia residency milestone project and American Board of Anesthesiology (ABA) content outlines required for written and oral examinations, there are currently no established standard didactic and rotation requirements (7). There have been a few recent attempts or proposals to establish such programs (8-9), however, the majority of US anesthesia residency programs are yet to implement specific POCUS didactics, simulations, and rotations. To gauge the current extent of POCUS training in anesthesia residency, surveys were conducted

in both US and China regarding the level of institutional exposure to an educational training given to POCUS.

## METHODS

### Questionnaire

A 22-question survey based on anesthesia provider POCUS experience was developed that could be sent electronically (Appendix 1).

### US Survey

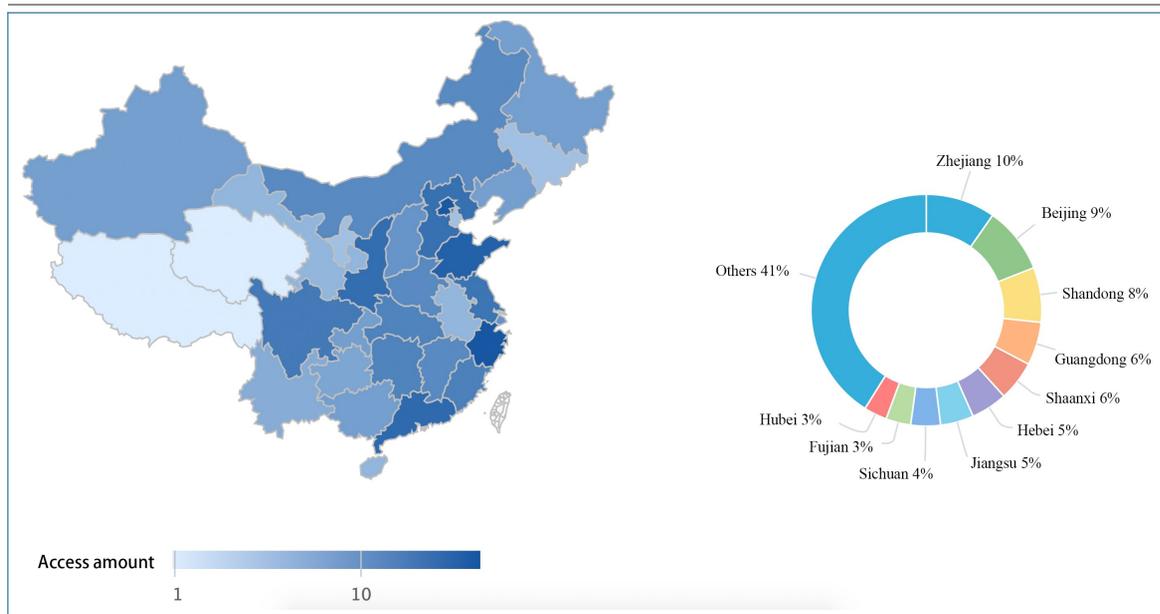
After approved by the institutional review board (IRB) of West Virginia University, an email was sent to the 147 US ACGME anesthesia residency programs with a link to the survey (Survey Monkey, Palo Alto, CA, USA). The United States survey only collected demographics in one area concerning respondent experience (resident or attending). Survey responses were collected over a two-month period.

### Chinese Survey

After approval from the committee of the New Youth Anesthesia Forum, an online questionnaire format with a computerized online survey program was used (Wenjuan.com, Zhongyan Network Technology Co., Ltd., Shanghai, China). A survey link to the questionnaire was published on the website (New Youth Anesthesia Forum) and only aimed at anesthesia providers working in an academic hospital setting with an associated residency program in anesthesiology in China. The respondents could choose to use a mobile device via WeChat (Tencent Holdings Limited, Shenzhen, China) or desktop to complete the survey. Each IP address is allowed to complete the survey once. The demographics of surveyed anesthesia health care providers obtained were for the geographic area of training and medical training levels (residents, attendings, vice chiefs, or chief physicians). All responses were gathered during a two-month survey period.

### Statistics

Survey responses numbers were converted into percentages and were used to summarize categorical variables. Continuous variables were summarized using the mean and standard deviation. To compare the two regions (United States



**Figure 1. Demographic Distribution of Chinese Survey Responses.**

Among the 424 Chinese survey responders, 10% came from Zhejiang Province, 9% came from Beijing, 8% came from Shandong Province, 6% came from Guangdong Province, 6% came from Shaanxi Province, 5% came from Hebei Province, 5% came from Jiangsu Province, 14% came from Sichuan Province, 15(4%) came from Fujian Province, 14(3%) came from both Hunan Province and Hubei Province, 12(3%) came from each of Inner Mongolia Autonomous Region, Jiangxi Province and Henan Province (12, 3%), 9(2%) came from both Shanxi Province and Shanghai, 7 (2%) came from each of Heilongjiang Province, Liaoning Province, Guangxi Zhuang Autonomous Region, Chongqing, and Xinjiang Uygur Autonomous Region, 1% came from Guizhou Province, 1% came from Yunnan Province, 1% came from each of Gansu Province, Anhui Province and Hainan Province, 1% came from each of Jilin Province, Ningxia Hui Autonomous Region and Tianjin, 0.25% from either Qinghai Province and Tibet Autonomous Region. Another 7% responders came from other regions.

and China), the Fisher-Freeman-Halton exact test (Fisher exact test for a 2-by-2 table) was used for categorical variables and continuous variables were compared using Welch’s t-test for unequal variances and unequal sample sizes. P values of less than 0.05 were considered statistically significant. Statistical analysis was performed using SPSS software (SPSS Inc., Chicago, IL, USA). Raw survey data and statistical values for statistical comparison of survey question responses are included in Appendix 1.

**RESULTS**

There were 130 individual respondents from

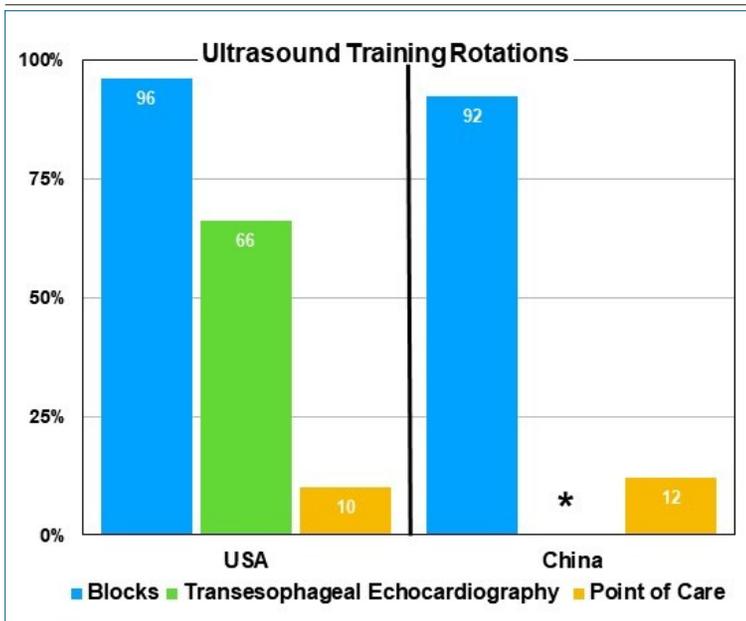
the 142 US ACGME programs surveyed and 394 individual respondents from the Chinese survey. For the US survey, no information was collected regarding for regional distribution of survey respondents, however the survey was sent to all US ACGME programs. The demographic distribution of Chinese survey responses is outlined in Figure 1.

**US Survey Responses**

US survey responses comprised of 48.5% responses from residents and 51.5% of responses from faculty. Overall, 96.2% of US respondents were affiliated with medical schools. Less than 50% of US respondents reported they had ultra



**Figure 2. Simulation Training Facility.** The percentage of US and China simulation training facility availability for Regional Block Transesophageal Echocardiography and Point of Care Ultrasound training.



**Figure 3. Ultrasound Rotations.** The percentage of US and China ultrasound training prevalence for Blocks, Transesophageal Echocardiography and Point of Care Ultrasound training rotations. N.B. The Transesophageal Echocardiography section of the Chinese data is set at 0.0% due to the Chinese TEE training not being a single course, rather as incorporated into other training rotations.

sound simulation facilities for regional nerve blocks (34.7%), TEE (40.8%), or POCUS training (30.4%). US training facilities for TEE, POCUS and regional nerve blocks are shown in Figure 2. Over 90% of US survey respondents had ultrasound-guided block training rotations. Less than 20% of US respondents reported having specific POCUS training rotations (Figure 3). US respondents reported overall low education resources (didactics, curricula, lectures, etc.) allocated for POCUS training (Figure 4). US respondents reported low attendance (participation of less than 50%) at POCUS workshops (Table 1).

**Chinese Survey Responses**

Chinese survey responses comprised of 27% responses from residents and 72% responses from either attendings, vice chiefs, or chief physicians. Overall, 53.55% of Chinese respondents were affiliated with medical schools. Chinese Ultrasound simulation facilities for Chinese regional nerve blocks were (56.1%), TEE (16.0%), and POCUS training (10.8%). Chinese training facilities for TEE, POCUS and regional nerve blocks are shown in Figure 2. Over 90% of

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**US-Chinese Comparisons of Survey Responses**

The US (66%) had significantly more responses for specific TEE rotations than Chinese institutions (8%;  $P < 0.001$ ). In regards to POCUS education; US respondents (36%) reported a significantly higher TTE rate training than China (24%;  $P = 0.003$ ) had, while China had significantly more ( $P < 0.001$ ) education in lung, abdominal, and other US training (airway, gastric, optic nerve, etc.).

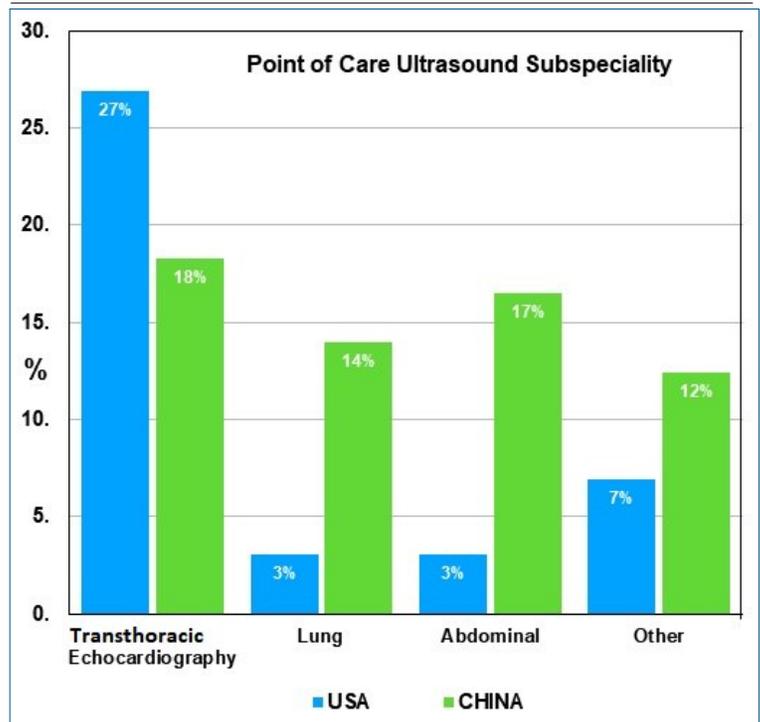
**DISCUSSION**

The responses of this dual country survey demonstrate that although POCUS training is a com-

ponent taught in many anesthesiology academic centers, it is not a universal training rotation. For the full utilization of this important anesthetic practice modality, there need to be significant increases in specific POCUS training and POCUS curriculums. Less than 1 in 5 anesthesiology residency programs in US and China have developed rotations for ultrasound despite the improvement in technology. Although there was not a systematic implementation of POCUS training/curriculum in US and Chinese academic anesthesia centers it appears that some momentum is progressing towards national POCUS practices (9). A Canadian survey about Focused Cardiac Ultrasound (FOCUS) training in residency program has been reported in the literature (10). However, the authors believe this reported study is the first POCUS training survey in the US and China. A survey of Canadian anesthesiology residency program directors on FOCUS observed that program directors recognized the importance of FOCUS training as 75% percent of Canadian anesthesia residency programs had some form of rotations in FOCUS (10) and 42% of programs had set minimum targets for FOCUS studies performed during training. In this Canadian study, much like the US and Chinese POCUS survey responses it POCUS programs include a lack of resources, expertise, standardized curriculum and standardized training requirements. Concerted efforts are required to address these barriers to implementation and national Anesthesia organizations should be designing and implementing national standardized POCUS guidelines and training courses.

Disparities in training and simulation opportunities were revealed by the survey. The existence of ultrasound physicians in China may explain lower response rates particularly in the area of TEE. There seems to be a relationship between training in ultrasound- guided regional, TEE and POCUS with respect to the availability of simulation modalities. Perhaps as more simulation opportunities become availability, training in these areas will increase.

Ultrasound- guided regional anesthesia and TEE rotations are common in anesthesiology residency programs. The utilization of these modalities are ubiquitous in sub-specialty areas of anesthesiology and due to its utility POCUS will like-



**Figure 4. Point of Care Ultrasound Subspecialty.** Percentages of US and China Point of Care Ultrasound subspecialty training for Transthoracic Echocardiography, Lung, Abdominal and Other training rotations.

	%	P-value
US	39.9	0.046
China	43.9	

ly expand in scope across anesthesia practice. This survey reveals that some programs are beginning to incorporate POCUS rotations and training into their curriculum. Currently, these programs are in the minority and there is room for continued advancement in the training of anesthesiology residents in POCUS. The lack of mandated rotations by the ACGME and recently and continuously developing technology coupled with the lack of training of many faculty anesthesiologists may account for this paucity of rotation opportunities. This survey reveals a potential weakness in anesthesiology training program in the US and China and an area of potential improvement for resident education going

forward.

Ultrasound technology has drastically improved in the past couple decades and the use of this technology for diagnostic and safety purposes in patient care will continue to increase in many specialties of medicine. POCUS usage has proven extremely useful in the realm of perioperative medicine and potential utilization will continue to expand. The ABA and ACGME have integrated ultrasound usage into board certification exams, training milestones, Objective Structured Clinical Examinations, and in expected topics for written examination. Although there are no standard POCUS training protocols

in the US or China, there are several reviews in the literature outlining detailed examples of developing POCUS focused curriculum and training procedures (9, 11-13).

This study highlights the need for formal national POCUS curriculums along with minimum training requirements which would enhance national adoptions of effective POCUS concurring with current anesthesia policy discussions that POCUS is both achievable and should be a high priority goal for specialty training programs (7).

The authors declare no other conflicts of competing interest for this work.

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**Appendix: Survey Questionnaire: Questions, Raw Data and Statistical Values.**

(For each survey question the first Question number denotes the US survey question order, the second Question number denotes the China survey question order [ e.g. Q4,Q6]) Data includes raw survey number responses, conversion to % and p-values where statistical comparisons where performed.	USA (n=130)	%	China (n=394)	%	P-value
Q1: what is your position					
Resident	63	48	108	27	< 0.001
Faculty	67	52	286	73	
Q2,N/A: does your department have access to an ultrasound training simulation lab	(n)	%	(n)	%	P-value
Yes	75	58			NA
No	53	41			
NR	2	1.5			
Q3,3: if your department does have access to ultra sound training simulation lab, does the lab have ultrasound guided block simulation facility	(n)	%	(n)	%	P-value
Yes	45	35	221	56	< 0.001
No	66	51	173	44	
NR	19	15	0	0	
Q4,Q6: if your department does have access to ultrasound training simulation lab, does the lab have a TEE simulation facility	(n)	%	(n)	%	P-value
Yes	53	41	63	16	<0.001
No	56	43	331	84	
NR	21	16	0	0	
Q5,Q11: if your department does have access to an alter sound training simulation lab does the lab have a POC simulation facility	(n)	%	(n)	%	P-value
Yes	40	31	41	10	< 0.001
No	67	52	353	90	
NR	23	18	0	0	
Q6,N/A: does your programs curriculum specifically include ultrasound guided regional blocks	(n)	%	(n)	%	P-value
Yes	124	95			NA
No	4	3.1			
NR	2	1.5			
Q7,N/A: if your programs curriculum specifically include ultra sound guided regional block do you have a specific regional block rotation	(n)	%	(n)	%	P-value
Yes	125	96			NA
No	3	2.3			
NR	2	1.5			
Q8,Q7: Does your program’s curriculum include TEE training	(n)	%	(n)	%	P-value
Yes	114	88	72	18	< 0.001
No	15	12	322	82	
NR	1	0.8	0	0	
Q9,Q8: if your program’s curriculum includes TEE, do you have a specific TEE rotation	(n)	%	(n)	%	P-value
Yes	86	66	32	8.1	< 0.001
No	39	30	40	10	

NR	5	3.9	322	82	
Q10,Q12: does your programs curriculum specifically include POC training	(n)	%	(n)	%	P-value
Yes	47	36	96	24	0
No	82	63	298	76	
NR	1	0.8	0	0	
Q11, Q14: if... Do you have a specific POC rotation	(n)	%	(n)	%	P-value
Yes	13	10	48	12	< 0.001
No	93	72	48	12	
NR	24	18	298	76	
Q12, Q13: if... Check all the modalities the curriculum includes	(n)	%	(n)	%	P-value
TTE	35	27	72	18	< 0.001
Lung	4	3.1	55	14	
Abdominal	4	3.1	65	17	
Other	9	6.9	49	12	
NR	78	60	298	76	
Q13,N/A: does programs didactic study include the topic of POC	(n)	%	(n)	%	P-value
Yes	56	43			NA
No	66	51			
NR	8	6.2			
Q14,Q16: do your departments grand Rounds include the topic of POC	(n)	%	(n)	%	P-value
Yes	59	45	92	23	< 0.001
No	67	52	302	77	
NR	4	3.1	0	0	
Q15,Q24: is your department affiliated with a medical school	(n)	%	(n)	%	P-value
Yes	125	96	211	54	< 0.001
No	5	3.9	183	46	
Q16,Q17: have you ever attended a POC workshop	(n)	%	(n)	%	P-value
Yes	57	44	157	40	0.05
No	71	55	237	60	
NR	2	1.5	0	0	
Q17,Q19: select if you have attended lectures/sessions on POC at any of the following meetings	(n)	%	(n)	%	P-value
National/Regional	17	13	152	39	< 0.001
Other	24	18	111	28	
None	83	64	11	2.8	
NR	6	4.6	237	60	
Q18,Q20: select the frequency that you use POC and your clinical anesthesia practice	(n)	%	(n)	%	P-value
Daily	12	9.2	55	14	0.14
Sometime	38	29	142	36	
Rarely	52	40	125	32	
Never	28	22	72	18	
Q19,Q21: if you NEVER use POC if your practice, select the frequency of others in your department to use POC in their clinical practice	(n)	%	(n)	%	P-value
Daily	18	14	52	13	< 0.001
Sometime	26	20	142	36	
Rarely	26	20	122	31	
Never	11	8.5	78	20	
NR	49	38	0	0	
	Mean	SE	Mean	SE	P-value
Q20,Q26: what is the total number of the faculty in your department	50.93	3.1	26.78	2.5	< 0.001

Q21,Q27-28: what is the total number of residents in your department	38.74	1.2	37.94	25	0.24
Q22, N/A: What percentage of the faculty uses ultrasound for:	(n)	%	(n)	%	P-value
Peripheral venous access	102	93	N/A	N/A	N/A
Invasive lines	108	98			
Regional blocks	110	100			
TEE	106	95			
Point of Care	98	89			