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Original Article

Does Simulation Work? Monthly Trauma Simulation and Procedural Training are Associated with Decreased Time to Intervention

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Short title: Trauma simulation and time to intervention

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Abstract

Background:

Establishing proficiency in specific trauma procedures during surgical residency has been limited to annual courses with limited data on its effect on the delivery of healthcare and patient outcomes. There is a wide variety of training on content and complexity with recent studies looking at time to imaging or secondary survey. In this study, we implement monthly case-based simulation after initial training on a variety of bedside trauma procedures. The overall goal is to evaluate the effect of simulation on time to specific interventions.

Methods:

This is a prospective, observational study between July 2018 and February 2019 at a single-institution, level I trauma center with a large surgical residency program. A trauma simulation program was implemented in November 2018 to train and evaluate surgical residents from PGY 1 through 5. All rotating residents participated in an initial course on basic trauma procedures, such as percutaneous sheath placement, tube thoracostomy, and resuscitative thoracotomy followed by an end-of-month simulation. All level I activations from pre-intervention starting in July-October 2018 (pre-intervention) and October 2018 through February 2019 (post-intervention) were reviewed; monitored variables included age, gender, mechanism of injury, blunt or penetrating, and time to intervention in the trauma bay. Median times to intervention were recorded with interquartile ranges (IQR). Pearson's coefficient was used to measure the strength of the relationship between simulation to time to patient intervention.

Results:

Median time to most interventions improved over time but with more consistent improvement after the implementation of formal simulation and procedural training in November 2018. Median pre-training time for resuscitative thoracotomy was 14 minutes (IQR 8-32); post-training median time was 3 minutes (IQR 2.7-8, $p=0.02$). Median pre-training time to tube thoracostomy was 13 minutes (IQR 5.5-19); post-training time was 6 minutes (IQR4-31, $p=0.04$). Pearson's coefficient (r^2) measured strength of correlation and was highest for tube thoracostomy followed by resuscitative thoracotomy and percutaneous sheath access with r^2 values of 0.46, 0.35 and 0.24 respectively.

Conclusions:

High-complexity, routine procedural training and trauma simulation are associated with decreased time to interventions within a short period of time. Routine implementation of a training program emphasizing efficient, effective approaches to bedside procedures is necessary to train our residents in these high-acuity, low frequency situations. Future investigations are warranted in the effect of simulation on short-term and long-term patient outcomes.

Level of Evidence:

Observational cohort study, Level III

Key Words: trauma simulation, resident performance, time to intervention

Introduction

Simulation-based training has been shown to improve performance and retention of procedural and leadership skills [1-4]. However, the clinical impact of these structured courses on resident performance remains unclear, specifically the time to patient-directed care, such as intubation, tube thoracostomy, vascular access, computed tomography (CT) scan, and operative intervention. The degree of the clinical impact of these courses has been limited to earlier studies on mortality rates [5] or time to completion of primary survey, such as intubation and transfusion [6]. To our knowledge, it is not known if standardized, repeated educational and simulation curriculum implemented in a trauma surgery rotation can affect clinical performance amongst surgical trainees.

High yield, effective teaching is paramount, particularly in a learning environment that has become increasingly non-operative, confined to an 80-hour work week with increasing emphasis on structured curricula and certifications in laparoscopic, robotic and other technical skills. This study aimed to evaluate the impact of routine monthly procedural and simulation training on time to intervention for trauma procedures. We hypothesize that implementation of this training will decrease time to intervention.

Methods

Study Design

We reviewed all trauma patients who met criteria for the highest-level trauma activation between July 2018 and February of 2019 at our institution, which is an urban, safety-net Level I Trauma Center. Patients meeting criteria were excluded if there was insufficient real-time documentation of patient interventions or if interventions were performed after the patient had left the trauma bay for diagnostic studies and returned for ongoing work-up and treatment. Enrollment process and refusal rates were not applicable as these patients were treated urgently as trauma-activations.

Data from the medical record was manually extracted at this institution and included demographics as age, gender, signs of life on admission, mechanism and specific type of injury. Patient interventions recorded included intubation, tube thoracostomy, vascular access, interosseous access, arterial line, resuscitative endovascular balloon occlusion of the aorta ("REBOA") device, pelvic binder, resuscitative thoracotomy, computed tomography and operative intervention. During these resuscitations, a dedicated trauma nurse clinician documents, in real-time and in the electronic medical record, time of the intervention.

Institutional board review was obtained for this observational study, which reviewed all patients meeting Level I trauma activation criteria at our institution from July 2018 through February 2019.

In November 2018, a formal trauma procedural training and simulation (herein summarized as 'training') program was launched to review high-yield procedures, including hands-on training for percutaneous sheath and arterial line placement, interosseous line, tube thoracostomy, resuscitative thoracotomy, tourniquet, pelvic binder, and REBOA. Training also emphasizes not only the technique but the basic knowledge of the equipment, set-up and physical location in the same trauma bay where we receive patients.

At the end of the trauma rotation, simulations were held and entailed a complex, ATLS-style scenario with a team leader, and designated roles for procedures and evaluation of the organization, flow and execution of procedures while two rooms focus specifically on procedural competency.

In this study, the recorded time to specific patient interventions was noted at a time-stamp and was viewed as a surrogate for team efficiency and dynamics. Time to patient intervention was calculated from the time the patient arrived at the trauma bay. Pre-training variables included patient gender, age, mechanism of injury, presence of signs of life on admission and time to various patient interventions as those described earlier in our trauma procedural training program. Post-training variables were identical to those above.

Statistics

Comparisons were made in before and after fashion, with July 2018 through October 2018 as the 'pre-training' period and November 2018 through February 2019 as the 'post-training' period. Median times to patient intervention were calculated with inter-quartile ranges (IQR). Student's T-test was used to evaluate for any statistical difference in time to intervention in the pre- and post-training periods. Pearson's coefficient was performed to assess the strength of correlation between training and time to patient intervention in both the before and after training time frames.

Results:

Patient characteristics

Between July 2018 and February 2019, there were a total of 294 Level I activations. 17 patients were excluded secondary to insufficient information on time to patient intervention.

The average age was 41 (SD 21) years with a median of 33 (IQR 15-100 years). Males accounted for most patients at 77%. Percentage of patients with vital signs on arrival was 87%. Blunt injuries were more common than penetrating (65% vs 35%). The most common mechanism of injury was motor vehicle accident (24%) followed by gun-shot wounds (21%), falls (17%), stab wounds (13%) and auto vs pedestrian (8%). Motor-cycle collisions and other traumatic injuries (assault, crush injuries) accounted for a minority of level I activations **(Table 1).**

Interventions

Amongst all interventions, leaving the trauma hall for computed tomography (CT) scan was the most common intervention, accounting for nearly 50% of events. We also considered this intervention as a surrogate for evaluation of team efficiency after completion of the primary and secondary surveys. Amongst procedures, endotracheal intubation consisted of approximately 13% of procedures, followed by operative intervention (12%), vascular access (7.2%), tube thoracostomy (6%), arterial line (4.6%), and resuscitative thoracotomy (3.6%). Interosseus line, pelvic binder, resuscitative endovascular balloon occlusion of the aorta (REBOA) remained a minority of procedures performed in the trauma bay **(Table 2).**

Time to Interventions

To evaluate the impact of procedural training and trauma simulation, we evaluated the time to intervention before initiation of training (July 2018 – October 2018) and post-training (November 2018 – February 2019). Median times to intervention pre-training were compared to post-training times. The median time to CT scan was 32.5 minutes pre-training (IQR 21-180); median time to CT scan post-training was slightly decreased to 30.5 (IQR 21-219, p=0.36). The median time to resuscitative thoracotomy pre-training was 14 minutes (IQR 8-32); post-training median time was 3 minutes (IQR 2.7-8, p=0.02). Median time to tube thoracostomy pre-training was 13 minutes (IQR 5.5-19); post-training median time was 6 minutes (IQR4-31, p=0.04). Pearson's coefficient was utilized to evaluate the strength of association of time to intervention and training pre-and post-implementation. This effect appeared to be most significant for tube thoracostomy, followed by resuscitative thoracotomy and percutaneous sheath access with r^2 values of 0.46, 0.35 and 0.24 respectively **(Table 3). Figure 1** demonstrates these trends over time.

Discussion:

Repetitive training with simulation is no foreign idea to the care of trauma patients. This idea stems over millennia during war-time conflict where soldiers took care of one another to help identify and readily address life-threatening injuries. Established over 40 years ago, ATLS and other formal training programs have evolved to meet the demands of trauma centers across the world to include not only knowledge, but technical skills and leadership.

From the inception of the Advanced Trauma Life Support ("ATLS") Course [7], there have been several efforts to educate, assess and enhance the dissemination of trauma resuscitation. As a result, much of surgical training for trauma resuscitation and procedures have evolved from these basic life-saving principles to provide efficient, evidence-based practices with the goal to improve patient care. More recently, there has been increasing emphasis to improve the performance and delivery of these life-saving procedures and resuscitation. These include early simulation utilizing ATLS didactics for medical students and military trainees in operational and military medicine [8,9], mannequin-based courses [10-13] to perfused cadaver [14] or animal-based models [15]. Additional studies have investigated the clinical impact of these interventions with focused outcomes on morbidity, mortality and time to operative intervention [16]. More recently, there has been increasing interest on a multi-disciplinary approach to trauma simulation training and reduced assessment time during primary and secondary surveys [17].

High yield, effective teaching of low frequency, high-acuity procedures in trauma resuscitation is multi-faceted and should be multi-disciplinary. However, faced with multiple other learning expectations and time-restrictions, the surgical trainee's learning environment that has become increasingly non-operative with less exposure to bedside trauma procedures in the face of a stressful, active resuscitation. In this study, we proposed that the implementation of a monthly trauma procedural training and simulation program not only helps improve resident performance but may improve time to specific interventions in trauma patients in the trauma bay before definitive care.

We found that monthly procedural training on high-yield procedures is associated with decreased time to patient intervention. This effect was especially pronounced in time to resuscitative thoracotomy, tube thoracostomy and percutaneous sheath placement.

There are of course a variety of factors that could affect the time to intervention, including PGY-level, patient acuity and other patient-specific factors (obesity, agitation, etc.), and time during the academic year. The intervention was timed about 4 months into the academic year when only a minority of residents had repeated their trauma rotation. Residents may also have had exposure to procedures such as vascular access and tube thoracostomy on other rotations, such as ICU and Cardio-thoracic surgery. Procedures are often performed by PGY-2 or PGY-3 residents, and time to procedure can vary based on level and number of procedures performed.

There are additional reasons that could affect time to intervention, including patient factors. Patients with depressed GCS, hypotension, suspected pneumothorax or hemothorax are more likely to undergo intervention as intubation, chest tube, percutaneous sheath placement and resuscitative thoracotomy. Based on the emergent nature of these procedures, they are employed quickly and simultaneously, often not requiring pain medication or sedation based on their depressed GCS. There are other specific patient factors that may affect the time to simulation, including morbid obesity, where placing a tube thoracostomy requires the entire length of the index finger for a sweep or a resuscitative thoracotomy may require two finochietto retractors based on a massive chest wall.

We also acknowledge that time to patient intervention is in many ways a surrogate of team efficiency. Time to a procedure not only includes the time for diagnosis and triage of a life-threatening problem (i.e. tension pneumothorax requiring chest decompression), but location of the equipment, preparation and actual placement. Team dynamics are also variable based on the communication and leadership skills of the team leader.

It is also difficult to analyze the actual effectiveness of our procedural training in a real environment with multiple patient and provider variables in comparison to a purely standardized environment where reality is suspended and the focus is on procedural task. We argue that the stress and complexity of actual trauma activations add layers of complexity to the procedure; stress and complexity are integral parts to resident-learning but are difficult to standardize.

Another limitation to this observational study is that our real-time documentation does not consistently include the start time in addition to end time of the procedures. Most of the documentation includes only end time of the procedure (i.e. pelvic binder secured, patient leaves trauma bay to CT scan). Our program is currently working on a quality improvement process to improve our real-time documentation based on video review.

Conclusion:

There are innumerable training and simulation programs to help teach and reinforce technical skill in bedside trauma procedures and resuscitation. In our study, we found that monthly high-yield procedural training and simulation may help decrease time to patient intervention. This effect was most significant in resuscitative thoracotomy, tube thoracostomy and percutaneous sheath placement. This effect of procedural training and simulation on patient outcomes has not yet been explored and remains an area for further research. We hope to trend this performance data over time to help identify deficiencies and strengths, and ultimately build an objective assessment tool specific to trauma and emergency procedures that can be utilized across other surgical training programs.

Study concept and design: Park, Cripps, Grant, Dumas, Scott, Luk

Data collection and analysis: Park, Cripps, Grant, Dumas, Dultz, Shoultz

Writing: Park, Cripps

Critical Revision: Park, Abdelfattah, Cripps

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References

1. Vestrup JA, Stormorken A, Wood V. Impact of advanced trauma life support training on early trauma management. Am J Surg, 1988. 155(5): p. 704-7.
2. Ali I, Cohen R, Reznick R. Demonstration of acquisition of trauma management skills by senior medical students completing the ATLS Program. J Trauma, 1995. 38(5): p. 687-91.
3. Ali J, Cohen R, Adam R, Gana TJ, Pierre I, Bedaysie H, Ali E, West U, Winn J. Teaching effectiveness of the advanced trauma life support program as demonstrated by an objective structured clinical examination for practicing physicians. World J Surg, 1996. 20(8): p. 1121-5; discussion 1125-6.
4. Brenner M, Hoehn M, Pasley J, Dubose J, Stein D, Scalea T. Basic endovascular skills for trauma course: bridging the gap between endovascular techniques and the acute care surgeon. J Trauma Acute Care Surg, 2014. 77(2): p. 286-91.
5. van Olden GD, Meeuwis JD, Bolhuis HW, Boxma H, Goris RJ. Clinical impact of advanced trauma life support. Am J Emerg Med, 2004. 22(7): p. 522-5.
6. Hedges JR, Adams AL, Gunnels MD. ATLS practices and survival at rural level III trauma hospitals, 1995-1999. Prehosp Emerg Care, 2002. 6(3): p. 299-305.
7. Collicott PE, Hughes I. Training in advanced trauma life support. JAMA, 1980. 243(11): p. 1156-9.
8. Cowan ML, Cloutier MG. Medical simulation for disaster casualty management training. J Trauma, 1988. 28(1 Suppl): p. S178-82.
9. Siriratsivawong K, Kang J, Riffenburgh R, Hoang TN. Immersion team training in a realistic environment improves team performance in trauma resuscitation. Surgery, 2016. 160(3): p. 586-90.

10. Marshall RL, Smith JS, Gorman PJ, Krummel TM, Haluck RS, Cooney RN. Use of a human patient simulator in the development of resident trauma management skills. J Trauma, 2001. 51(1): p. 17-21.
11. Block EF, Lottenberg L, Flint L, Jakobsen J, Liebnitzky D. Use of a human patient simulator for the advanced trauma life support course. Am Surg, 2002. 68(7): p. 648-51.
12. Fernandez GL, Page DW, Coe NP, Lee PC, Patterson LA, Skylizard L, St Louis M, Amaral MH, Wait RB, Seymour NE. Boot cAMP: educational outcomes after 4 successive years of preparatory simulation-based training at onset of internship. J Surg Educ, 2012. 69(2): p. 242-8.
13. Sparks JL, Crouch DL, Sobba K, Evans D, Zhang J, Johnson JE, Saunders I, Thomas J, Bodin S, Tonidandel A, Carter J, Westcott C, Martin RS, Hildreth A. Association of a Surgical Task During Training With Team Skill Acquisition Among Surgical Residents: The Missing Piece in Multidisciplinary Team Training. JAMA Surg, 2017. 152(9): p. 818-825.
14. Grabo DJ, Polk T, Strumwasser A, Inaba K, Foran C, Luther C, Minneti M, Kronstedt S, Wilson A, Demetriades D. A Novel, Perfused-Cadaver Simulation Model for Tourniquet Training in Military Medics. J Spec Oper Med. 18(4): p. 97-102.
15. Perkins RS, Lehner KA, Armstrong R, Gardiner SK, Karmy-Jones RC, Izenberg SD, Long WB 3rd, Wackym PA. Model for Team Training Using the Advanced Trauma Operative Management Course: Pilot Study Analysis. J Surg Educ, 2015. 72(6): p. 1200-8.
16. Murphy M, Curtis K, Lam MK, Palmer CS, Hsu J, McCloughen A. Simulation-based multidisciplinary team training decreases time to critical operations for trauma patients. Injury, 2018. 49(5): p. 953-958.
17. Long AM, Lefebvre CM, Masneri DA, Mowery NT, Chang MC, Johnson JE, Carter JE. The Golden Opportunity: Multidisciplinary Simulation Training Improves Trauma Team Efficiency. J Surg Educ, 2019. 76(4): p. 1116-1121.

Tables

Patient Factors and Mechanism of Injury	
Total Level I activations	277
Age, median (range)	33 (12-100)
Male, n/total (%)	214/277 (77)
Mechanism n/total (%)	
MVC	67/277 (24)
GSW	58/277 (21)
Fall	49/277 (18)
SW	37/277 (13)
AVP	23/277 (8)
MCC	14/277 (5)
Blunt, n/total (%)	181/277 (65)
Vitals signs on arrival n/total (%)	241/277 (87%)

Table 1. Patient Demographics and Mechanism of Injury. MVC = motor vehicle collision. GSW = gun-shot wound. SW= stab wound. AVP=auto vs pedestrian. MCC = motor cycle collision.

Intervention	Count, n (%)
Intubation	52 (13)
CT scan	176 (45)
OR	47 (12)
Tube thoracostomy	25 (6)
Percutaneous sheath	28 (7.2)
Arterial line	18 (4.6)
Resuscitative thoracotomy	14 (3.6)
Interosseus line	5 (1.2)
Pelvic binder	5 (1.2)
Tourniquet	3 (<1)
REBOA	2 (<1)

Table 2. Total number of procedures. CT = computed tomography, REBOA = resuscitative endovascular balloon occlusion of the aorta.

Intervention	Median Time to Intervention [minutes, pre-simulation, (IQR)]	Median Time to Intervention [minutes, post-simulation, (IQR)]	p value	r^2
Resuscitative Thoracotomy	14 (8-32)	3 (2.7-8)	0.02	0.35
Tube Thoracostomy	13 (5.5-19)	6 (4-31)	0.04	0.46
Introducer Sheath	12 (9-30)	7 (6-80)	0.14	0.24
CT scan	32 (21-316)	31 (21-219)	0.36	0.06
OR	16 (10-86)	28 (15-106)	0.07	0.11

Table 3. Median time to intervention pre- and post simulation (minutes with interquartile ranges). r^2 = Pearson's coefficient

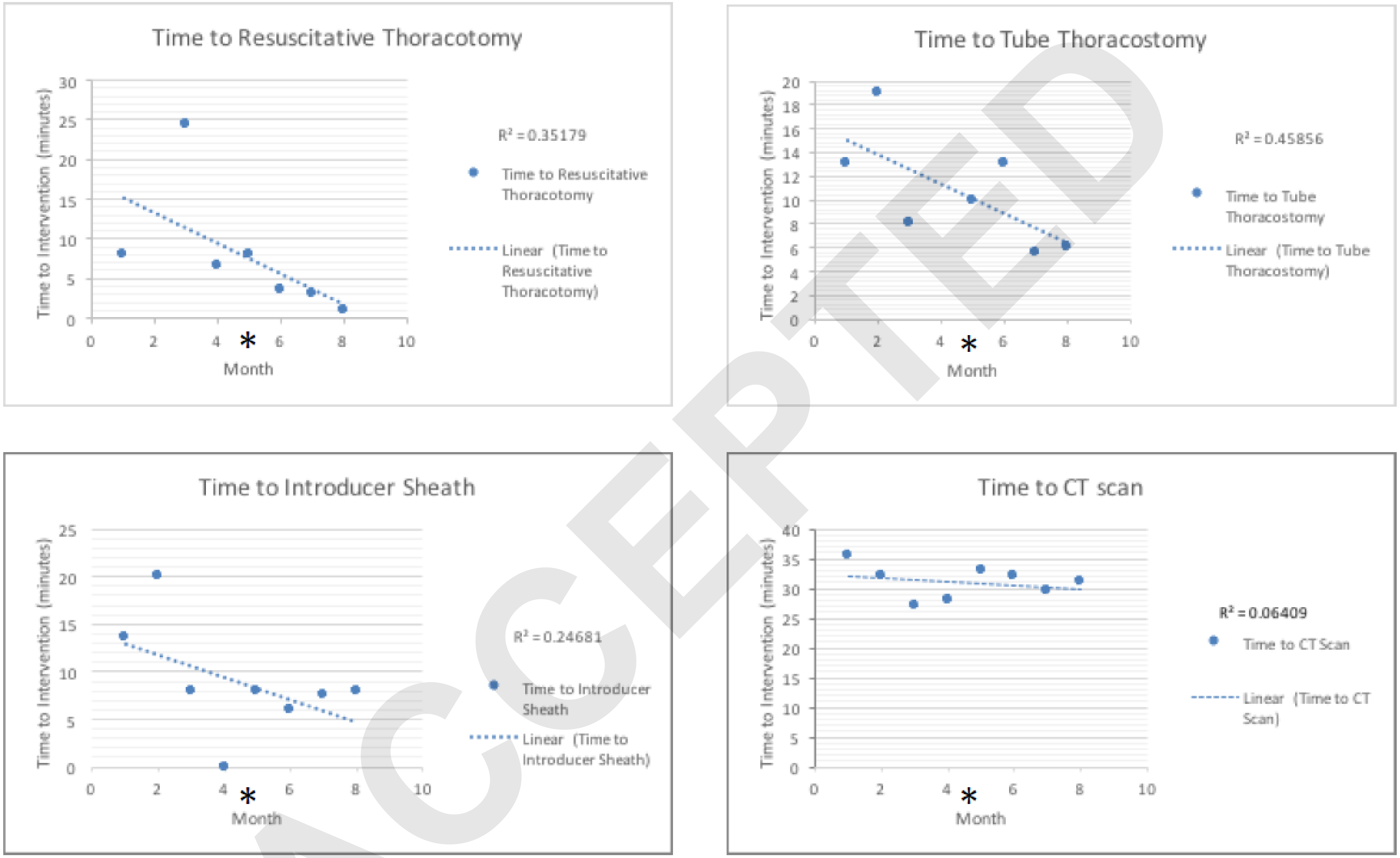

Figure 1. Time (minutes) to patient intervention over time (months). Asterisk * denotes implementation of procedural training and simulation.