Filling in the Gaps of Predeployment Fleet Surgical Team Training Using a Team-Centered Approach

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ABSTRACT

Introduction: Teamwork and successful communication are an essential part of any medical specialty, especially in the trauma setting. United States Navy physicians developed a course for deploying Fleet Surgical Teams to reinforce teamwork, communication and baseline knowledge of trauma management. *Method:* The course combines 22 hours of classroom didactics along with 28 hours of hands-on simulation and cadaver-based laboratories to reinforce classroom concepts. It culminates in a six-hour, multi-wave exercise of multiple, critically-injured victims of a mass casualty and utilizes the "Cut-Suit," which enables performance of multiple realistic surgical procedures as encountered on real casualties. Participants are graded on time taken from initial patient encounter to disposition and the number of errors performed. Pre- and post-training written examinations are also given. The course is graded based on participants' evaluation of the course. *Results:* Overwhelming number of the participants indicated that the course promoted teamwork, enhanced knowledge and gave confidence. Only 51.72% of participants felt confident in dealing with trauma patients before the course, while 82.76% felt confident after (p-value 0.01). Both the time spent on each patient and the number of errors made also decreased after course completion. *Conclusion:* The course was successful in improving teamwork, communication and base knowledge of all the team members. It should be an essential part of Fleet Surgical Team pre-deployment readiness.

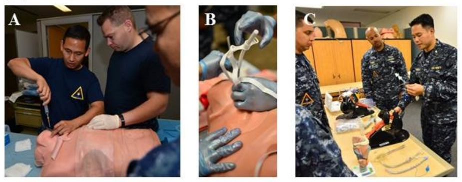


Figure 1: *Airway Management Sim-Lab.* (A) & (B) CDR Hoang is demonstrating how to perform percutaneous cricothyroidotomy. (C) LCDR Gambala, the anesthesia provider with extensive experience during his deployment to Afghanistan, demonstrating appropriate airway management techniques to the course participants.

INTRODUCTION

Teamwork and successful communication are an essential part of any medical specialty, especially surgery. As such, even the most skillful surgeon will have suboptimal patient outcomes without a strong team. McLaughlin et al[1] noted that "common factors for [successful healthcare] include a cohesive and well-integrated team structure with well-defined procedural organization. Although a multidisciplinary work force has clear advantages for improving today's quality of care, teamwork is not intuitive and requires training, guidance, and executive support." Not surprisingly, any breakdown in effective teamwork and communication will be detrimental, especially in the complex, fast-paced combat mass casualty care arena. Miller et al[2] recognized the significance of this concept and implemented an in-situ trauma simulation program at a Level One trauma center, which showed improvement in both teamwork and communication. Fleet Surgical Team Three (FST-3), an operational unit of the United States (US) Navy, has also identified the significance of this crucial team phenomenon and has developed a course requiring participants to integrate the teamwork and communication necessary to effectively care for critically injured patients and respond to mass casualty situations. The training further promotes team cohesion by standardizing patient-centered knowledge across all participants in addition to making each aware of their individual role on the team.

Surface US Navy pre-deployment medical training has traditionally focused on individual, first-responder readiness or on medical department mass casualty exercises, which tend to focus on patient transport and triage. However, these provide minimal training on specific injury patterns and their management. The Fleet Surgical Team Pre-deployment Trauma Training Course (FST PTTC) is designed to specifically address this critical gap in medical preparedness. It employs a team-based approach to educate personnel from corpsmen to physicians on how to effectively triage, stabilize, treat, and disposition a broad range of injured patients that may be encountered during deployed shipboard operations.

The course combines twenty-two hours of classroom didactics with twenty-eight hours of hands-on simulation and cadaver-based laboratories to reinforce classroom concepts. The course is accredited by the Naval Medical Center San Diego, San Diego, California and awards fifty-six American Medical Association Physician's Recognition Award Category 1 Continued Medical Education credits for medical providers enrolled in the course. The classroom curriculum stresses the best practices drawn from civilian trauma, recent military combat trauma experience, and clinical practice guidelines that are currently used in theater. It also emphasizes common pitfalls encountered in medical practice. Lecture topics include military trauma triage, basic trauma physiology, shipboard blood product utilization, pain management, and multiple complex trauma injury patterns, to name a few. Focused lectures provide team members with practical information on how Level-2 facilities, such as the Landing Helicopter Assault/Landing Helicopter Dock amphibious assault platforms, can successfully deal with a variety of injury patterns potentially seen on expeditionary deployments. These lectures center around shipboard emergencies such as fire, man overboard, and combat wounds from penetrating, blast mechanisms, and complex combinations of the above from amphibious operations.

The didactic topics are then incorporated into simulation laboratory (Sim-Lab) sessions utilizing physiologic and procedural trainers to reinforce key concepts and employ hands-on experience (Figures 1). Cadaver laboratories ensure that participants appreciate the anatomic complexity and tactile experience of performing procedures on human tissue. The course concludes with a six-hour, multi-wave session of critically-injured, multi-victim, mass-casualty exercise utilizing the Human-Worn Partial-Task Surgical Simulator ("Cut-Suit"). The "Cut- Suit" is an anatomically accurate simulator that can be safely human-worn and allows for the performance of a variety of complex, realistic surgeries and procedures as encountered in real casualties. This provides the team with numerous opportunities to operate in a realistic, high stress, and fast-paced environment. Participants perform triage, resuscitation, surgical operations, post-operative care, packaging, and evacuation all while managing critical, multi-layer communication, patient tracking, and organized flow.

This course is unique to the Fleet Navy with its team-based approach to medical training, specifically trauma resuscitation. It parallels a similar course taught at the US Marine Corps (USMC) 1st Medical Battalion, but it applies concepts specific to the shipboard and amphibious combat environments and is enhanced by the introduction of cadaver laboratories and amphibious assault injury scenarios.

Time to Patient Disposition

FST Pre-deployment Trauma Training Course						Mass Casualty								
						Scenario 1			Scen 2	Scenario 3				
Team	BedTeam	Team Leader Specialty	Pre 1Pt (min)	Post 1Pt (min)	Time Improvement	Pt 1	Pt 2	Pt 3	Pt 1	Pt 1	Pt 2	Pt 3	Pt 4	Pt 5
FST 3	1	FP	25	13	12		8	31	10		18	20	60	
	2	GS	18	11	7	7				12				
FST 5	1	FP	38	18	20	20			15	27				
	2	FP	19	10	9		15	9			22		10	
	3	GS										15		
Dummy	1	GMO	30											
		Time to complete	100	52	Improvement	48 min								
		Mean	25	13		12								
			9.201	3.559	StDv	5.715								

Number of Critical Events Missed*

FST Pre-deployment Trauma Training Course						Mass Casualty								
						Scenario 1			Scen 2	Scenario 3				
FS Team	BedTeam	Team Leader Specialty	Pre 1Pt count	Post 1Pt count	Critical error improvement	Pt 1	Pt 2	Pt 3	Pt 1	Pt 1	Pt 2	Pt 3	Pt 4	Pt 5
FST 3	1	FP	5	0	5		0	2	0		0	0	0	
	2	GS	5	1	4	0				1				
FST 5	1	FP	6	2	4	0			0	0				
	2	FP	6	1	5		1	2			0		0	
	3	GS										0		
Dummy	1	GMO	7											
		Error count	22	4	Improvement	18								
		Mean	5.5	1		4.5								
		StDv	0.577	0.816	StDv	0.577								

*Bed setup/ prep/ recognition of injury patterns
Airway management/ IV adjustment/ CXR-FAST
Communication/ Blood Bank management/ Hemorrhage control

Table 2: *Data from the FST-3 and FST-5 training during the course.* The time to complete the task from pre- to post-course assessment: Individually, participants decreased time to completion from a mean of 25 minutes to 13 minutes; As a team, they decreased time to completion by 48 minutes total; The critical errors decreased from a mean of 5.5 errors per subject to 1 error; As a team, they decreased critical errors by a count of 18; The time to complete the task Pre-course: mean of 25 ± 9.201 minutes; The time to complete the task Post-course: mean of 13 ± 3.559 minutes; The improvement in time to complete the task value: mean 12 ± 5.715 minutes; The critical error pre-course: mean 5.5 ± 0.577; The critical error post-course: mean 1 ± 0.816; The improvement (critical errors missed) value: mean 4.5 ± 0.500. Pt is patient, CXR is chest X-ray, FP is family practice, GS is general surgery.

MATERIALS AND METHODS

Course Design:

The Fleet Surgical Team Pre-deployment Trauma Training Course took place over eleven days, the layout of which is demonstrated on Tables 1. Day eleven signaled completion of the course and culminated in a six-hour, multi-wave of multiple, critically-injured victims of a mass casualty exercise that utilized the "Cut-Suit." Using the "Cut-Suit" enabled performance of multiple realistic surgical procedures as encountered on real casualties (Figure 2).

Evaluations and Data Collection:

At the end of each day, the participants are asked to evaluate each instructor and the topics presented based on delivery, content, details, applicability and practices on a scale of one (strongly disagree) through five (strongly agree). Data is also collected during the multi-wave, mass casualty scenarios, specifically on the time it took to correctly manage each patient and the number of errors that were made during this process. After the mass casualty simulation, the participants are asked to evaluate the course overall with a 15 question survey (Figure 3 Right).

A 25 question multiple-choice written exam is administered to the course participants at the beginning of the week and again after the course to measure improvements in fund of knowledge. This is important because the course is taught to multiple levels of healthcare providers with differing levels of experience from hospital corpsmen to nurses and physicians. The exam was included in the course for the second of the FSTs and data is not included here as it is still being analyzed.

Statistical Analysis:

All items were analyzed in terms of descriptive statistics and reported as means with standard deviations (StDv). Significance was determined with chi-squared value of 6.343. Statistical testing was performed using Microsoft Excel 2010 for PC (Microsoft Corporation, Redmond, Washington).

Figure 2: *Mass Casualty Exercise.* (A) The Cut-Suit is simulating a cardiac arrest in the OR, necessitating initiation of CPR. The CPR is in progress, and the emergent thoracotomy is being set up. The team has successfully stopped the hemorrhage from the left lower extremity amputation with the tourniquet. (B) The Cut-Suit is simulating an improvised explosive device blast, resulting in multiple chest, abdominal wounds, traumatic amputation, and severe shock. (C) The Cut-Suit is simulating exploratory laparotomy for multiple abdominal shrapnel wounds.

RESULTS

Thus far, there have been a total of two FST PTTCs conducted and the data is being presented here. The primary objectives of the course were to emphasize and improve teamwork by effective communication, as well as instill the baseline knowledge of trauma care for all team members. The participants were divided into teams with a physician as the team leader. Two and three resuscitation "bed teams" were created during FST-3 and FST-5 groups, respectively, for a total of 5 "bed teams" who completed the training course (n=29). A standardized evaluation form was developed to grade each "bed team" (Figure 3 Left). The teams were first assessed at the start of the course to obtain baseline performance (Pre 1Pt on Table 2). They were evaluated again upon completion of the course (Post 1Pt on Table 2). Part of the evaluation consisted of time taken to appropriately triage, treat, and finalize the patients' disposition with the least number of errors. Time started with the initial encounter and ended with the final disposition. Individual "bed teams" improved their time from a mean of 25 (± 9.201) minutes to 13 (± 3.559) minutes. A reduction in the mean critical errors per "bed team" was also noted (5.5 ± 0.577 errors in the initial evaluation and 1 ± 0.816 errors in the final evaluation).

The setups of the FST-3 and FST-5 courses varied due to personnel manning and thus influenced the outcomes during the mass casualty scenarios. FST-3 consisted of two, fully-functional teams with two monitored beds and one unmonitored, unattended ("overflow bed"). FST-5 was made up of three fully functional teams with three monitored beds. It was noted that the two FST-3 teams were able to successfully handle two simultaneous casualties, but the third patient in the "overflow bed" experienced delay in care (Scenario 1 on Table 2). During the third scenario, the FST-3 teams made adjustment which enabled them to effectively triage and treat three patients with still only having two fully staffed and equipped bed teams. Unfortunately, the fourth patient also experienced the delay of care due to lack of staff and equipment (Scenario 3 on Table 2). On the other hand, the three FST-5 teams successfully maintained performance during all three scenarios (Table 2).

At the completion of each Sim-Lab, the participants were asked to grade the appropriateness of the delivery, content, details, applicability and practices on a scale of one (strongly disagree) to five (strongly agree) (Graph 1). Of the participants, 73.03% ± 14.123 strongly agreed that the Sim-Labs were appropriate in content, 74.07% ± 15.951 strongly agreed that Sim-Labs contained appropriate amount of detail, 73.67% ± 16.682 strongly agreed that the Sim-Labs were applicable to their practices, and 57.25% ± 21.810 strongly agreed that the Sim-Labs coincided with their medical practice protocols.

The participants were also asked to evaluate the course overall on a scale of one (not helpful) through ten (very helpful) (Graphs 2, Figure 3 Right). Scores 1 through 4 were considered as being "not helpful", scores 5 through 7 were considered as being "helpful", and scores 8 through 10 were considered as being "very helpful." The overwhelming majority of the participants rated the course as being "very helpful" when asked the following: materials are focused and relevant to my coming deployment, the didactics helped set the tone and focus for my job, the didactics helped set the tone and focus the team for the job, the Sim-Lab helped focus what I need to know for my coming deployment, the instructors were knowledgeable in their lecture topics, the "Cut-Suit" practical application was critical in helping bring the team together, I would recommend the course to other FST teams, I would recommend the course to ship medical, and this course would be beneficial to US Navy/Marine Corps medical integration (Graph 2, Table 2).

Further, 100% of participants felt that the course was "very helpful" (rated 8-10) in the following areas: the course helped prepare me for possible trauma encounters on my coming deployment (StDv 4.509), the Sim-Lab helped focus the team (StDv 6.429), the Sim-Lab helped individuals to come together and function as a team (StDv 7.371), and the course helped the team to function as a cohesive unit (StDv 7.321, Graph 2, Table 2). Lastly, when evaluating confidence, only 51.72% ± 1 of the participants felt confident with complex traumas prior to the course, while 82.76% ± 3 were confident upon completion. The null hypothesis of no difference is rejected based on statistical significance (with one degree of freedom and a chi-squared value of 6.343, the p-value is 0.01, indicating that the course made a significant difference on perceived confidence).

Day One	Day Two	Day Five	Day Six
0930 Course Introduction; 0935 Triage in mass casualty - Understand triage in Level II facility - Compare & contrast triage in routine & mass casualty; 0955 Enroute care - Understand Enroute Care concepts - Equipment & team members - Techniques & capabilities - Priorities, limitations, issues with current system; 1015 Trauma code - ATLS outline & video - Understand goals; 1035 Trauma team roles - Understand tasks assigned to each member of trauma team; 1055 Break; 1105 Airway – Bagging, Intubation & Cricothyroidotomy - Airway issues specific to shipboard environment - Constraints - Important approaches, techniques to improve outcome; 1125 Pneumothorax - needle decompression & chest tube - Indication for intervention - Understand indications and goals - Approaches, techniques to improve outcomes - Pitfalls and limitations; 1200 Lunch; 1230 Cadaver lab - Airway - Needle decompression - Tube thoracostomy - Thoracotomy - IO access & CVL placement - Venous cutdown - Extremity & pelvic external fixation device - Fasciotomy	0930 Fluid resuscitation & Massive transfusion protocol - Understand definition and shipboard transfusion capability - Consequences of massive transfusion - Permissive hypotension - Techniques that improve outcome; 1000 Walking blood bank - Overview of walking blood bank policy & instruction - Timing, logistics, equipment - Deglycerolization of frozen blood; 1030 Break; 1040 Trauma bags - Concept & contents; 1100 Lethal triad – hypothermia, acidosis, coagulopathy - Patterns of injury - Approaches, techniques to improve outcomes - Pitfalls & limitations; 1130 Lunch; 1230 Sim-Lab 1 - FST skills lab - Airway - Cricothyroidotomy - Suturing - IO access; [illegible] Medical Regulating & Control Officer / Medical Administration Officer role - Function & pitfalls; 1140 Lunch; 1330 Sim-Lab 2 - Trauma team role familiarization - ATLS overview - Airway scenario	1230 Long bone fractures, dislocations, compartment syndrome - Patterns of injury - Approaches, techniques to improve outcomes; 1300 Blunt trauma / Blast injury - Patterns of injury - Approaches, techniques to improve outcomes - Pitfalls & limitations; 1330 Amputation / Vascular - Patterns of injury - Approaches, techniques to improve outcomes - Pitfalls & limitations; 1415 Sim-Lab 3 - Multiple fractures - Traumatic amputation	0930 Catheterization - Technique, pitfalls; 0945 Spine Injuries - Patterns of injury - Approaches, techniques to improve outcomes - Pitfalls & limitations; 1015 Drowning - Approaches, techniques to improve outcomes - Pitfalls & limitations; 1045 Break; 1055 Burns & electrocution - Patterns of injury - Approaches, techniques to improve outcomes - Pitfalls & limitations; 1125 Lunch; 1230 Sim-Lab 4 - Drowning with hypothermia - Spinal injury with shock

Day Nine	Day Ten
0930 CNS injury - Patterns of injury - Approaches, techniques to improve outcomes - Pitfalls & limitations; 1000 Shipboard Toxic Exposure - Liquid fuel & toxic gas exposure - Ingestion, Inhalation, & Contact effects - Pharmacologic toxins - Acetaminophen - General overdose management principles; 1030 Break; 1040 Pelvic fracture / Urogenital trauma - Patterns of injury - Approaches, techniques to improve outcomes - Pitfalls & limitations; 1140 Lunch; 1230 Sim-Lab 6 - Multiple casualty with polytrauma, burns & blasts - Multiple traumatic amputations - Chest injury	0900 Sim-Lab 7 - Multiple casualty with polytrauma, burns & blasts - Multiple traumatic amputations - Chest injury; **Day Eleven** 0900 Mass Casualty Exercise

Table 1: *FST PTTC Detailed Schedule Description.* FAST is focused assessment with sonography in trauma, ATLS is advanced trauma life support, US is ultrasound, IO is intraosseous, CVL is central venous line, OR is operating room, BLS is basic life support, ACLS is advanced cardiac life support, ICU is intensive care unit. CNS is central nervous system.

DISCUSSION

Medical errors are an unfortunate but significant part of healthcare delivery. In 1999, the Institute of Medicine (IOM) reported that nearly 100,000 deaths occur annually due to medical errors, costing an estimated $25 billion.[3] The IOM concluded that implementation of team training programs could be an integral part in error reduction.[3] More recently, Classen et al[4] noted that overall medical errors occurred in 33.2% of hospital admissions in the US, or 91 events per 1,000 patient days. As there is already a high rate of medical errors in controlled medical settings, the increased stress and added chaos of mass casualties and deployments may contribute to an even greater number of errors in patient care for military casualties. Fleet Surgical Team Three has been one of few to note the lack of team training, effective communication, and multidisciplinary preparedness prior to medical personnel deployment that may be to blame. The Fleet Surgical Team Pre-deployment Trauma Training Course is designed specifically to address this critical gap in training.

There is currently no training being offered within the Fleet Navy (Blue-side) medical community that is analogous to this course. The FST PTTC has already proven itself to be an invaluable tool in preparing units such as the FSTs for deployments. An additional role of this type of training includes providing integrated training between the shipboard medical departments and embarked medical personnel directly supporting expeditionary USMC units in order to improve the capability of healthcare providers to care for multiple, traumatically-injured patients.

During the six-hour, multi-wave, mass casualty simulation utilizing the "Cut-Suit," teamwork and effective communication were found to be a crucial element in successful patient care. The FST-3 group was limited in the number of beds and personnel, resulting in delay of care for the third patient in the first scenario. Applying the lessons learned to future mass casualty experiences, they were able to organize a much better patient flow for the subsequent scenarios. This again strongly emphasizes the impact of team communication, cohesion, and effort. It should be pointed out that during the third scenario, FST-3 and FST-5 were varied in the time it took to care for the fourth patient, with FST-5 taking much shorter time than FST-3. This can be explained by the limitations placed on FST-3 from the provider and supply perspective. Thus, despite adequate and efficient training, limitations in personnel, supplies, and space will likely remain rate-limiting steps in patient management during mass casualty situations. This encourages an even greater emphasis on team training to avoid adding yet another limitation to effective patient care during mass casualties.

The impact that this course has had on already-trained medical providers is astounding. With over 90% of the participants rating this hyper-realistic training as being very helpful, there is no question as to whether or not additional mass casualty training exercises are necessary for medical personnel, especially in the military setting. With new training technology, programs are now capable of simulating realistic scenarios, environments, and stressors that even healthcare providers with many years of experience are still in need of. By addressing the need for team and group training prior to deployment, this course offers a potential solution to this deficit. However, stopping with just a single training course will likely not yield long lasting positive results. As noted by Miller et al,[2] the observed benefits of the simulation training significantly declined once the simulation program was stopped in their Level One trauma center. We also agree that a likely key to maintaining successful outcomes is through continuous reinforcement of teamwork and communications, as well as baseline trauma knowledge. We will retest and reinforce the topics covered and the skills learned during this course with the current participants within six months of their course.

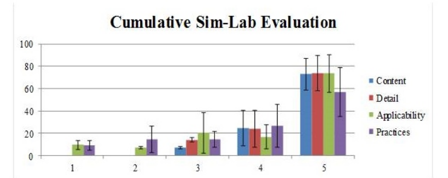
FST 1/3/5/9 Trauma Team Resuscitation/CUT-SUIT evaluation (circle one):
Date:
Team leader:

1. Resuscitation time begin: time of disposition decision: time end: total:
2. Number of critical events missed:
   - Bed setup/prep
   - Recognition of pattern of injury
   - Airway management
   - IV access
   - Hemorrhage control
   - CXR/FAST
   - Team communication
   - Blood bank
   - Operative management
   - Evacuation
3. Team Procedure expertise (rate from 1-10):
   a. Rapid recognition of procedures required:
   b. Appropriate designation of procedure experts:
   c. Expertise of procedure performed:

Evaluator:

Questions asked:	Not Helpful %±StDv	Helpful %±StDv	Very Helpful %±StDv
1. Materials are focused and relevant to my coming deployment	0±0	20.69±1.414	79.31±0.577
2. The course helped prepare me for possible trauma encounters on my coming deployment	0±0	0±0	100±4.509
3. The didactics helped set the tone and focus for my job	3.45±0	17.24±0	79.31±1.528
4. The didactics helped set the tone and focus the team for the job	3.45±0	3.45±0	93.10±4.359
5. The Sim-Lab helped focus what I need to know for my coming deployment	0±0	17.24±2.121	82.76±5.196
6. The Sim-Lab helped focus the team	0±0	0±0	100±6.429
7. The Sim-Lab helped individuals to come together and function as a team	0±0	0±0	100±7.371
8. The course helped the team to function as a cohesive unit	0±0	0±0	100±7.371
9. The instructors were knowledgeable in their lecture topics	0±0	3.45±0	96.55±6.807
10. The "Cut-Suit" practical application was critical in helping bring the team together	3.45±0	10.34±0.707	86.21±7.506
11. I would recommend the course to other FST teams	0±0	3.45±0	96.55±7.767
12. I would recommend the course to ship medical	0±0	3.45±0	96.55±8.737
13. This course would be beneficial to Blue Green integration	0±0	6.90±0	93.10±5.568
14. Having taken the course, I believe my confidence level for these complex traumas before the course was	13.79±1.414	27.59±1.155	51.72±1
15. My confidence level after the course for these complex traumas was	0±0	10.34±0.707	82.76±3

Figure 3. (Left) *The Standardized Participating Team Evaluation Form;* (Right) *The Course Evaluation Questionnaire and Responses.* Corresponds with Graphs 2.

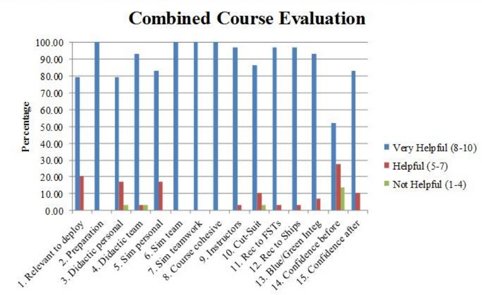


Graph 1: *Participants' evaluation of the Sim-Labs:* scale of 1 through 5. (1) Strongly disagree, (2) Disagree, (3) Neither agree nor disagree (4) Agree, (5) Strongly agree. The error bars represent StDv.

CONCLUSION

From the data, it can be concluded that the Fleet Surgical Team Pre-deployment Trauma Training Course is not only beneficial to the individual medical providers, but it is also crucial to enhancement and efficacy of team performance in the trauma setting. The data proves that despite personal competencies in practice, functioning as a member of a team is a skill that must be trained and fine-tuned. From the pre- to post-course testing, robust improvements were noted in the time taken to triage, care for, and disposition a patient as well as in the errors made during the exercises. Individually, the participants improved, but most notably were those improvements made in the overall team statistics. This correlates well with the previous works showing promising results of improved teamwork in team-centered simulation training.[2,5]

Finally, from the course evaluations on appropriateness, effectiveness, relativity to deployment, use of didactics and simulators, and confidence resulting from the course, it can be concluded that the course has significant value and future implications in training Fleet Surgical Teams prior to deployment. Furthermore, the team performance after the course can potentially be used in operational planning, calculating the number of FSTs required for a specific engagement based on the projected casualty numbers.



Graph 2. *The Combined Course Evaluation.* Showing the percentage of participants that graded different parts of the course as being very helpful, helpful or not helpful. Of note, questions 14 and 15 represent the participants' confidence before and after the course respectively. The participants were asked to put a numerical value to their confidence level on the scale of one through ten.

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