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The Role of Structured Framework in Simulated Cardiac Emergency for Cardiothoracic Training

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Abstract

Background: Both technical and nontechnical skills are important factors in cardiac emergency incident. The effects of structured framework on these skills have not been thoroughly studied. We hypothesized that structured framework can improve the clinical performance and reduce errors to improve patients' safety. **Methodology:** A total of 24 teams composed of cardiac residents, attending surgeons and ICU nurses performed simulated emergency incident tasks in cardiopulmonary resuscitation (CPR) and tracheal intubation (TI) scenarios. Framework education was introduced to the assigned groups in two separate semesters. All the scenarios were recorded by video for further evaluation by cardiologist and emergency medicine specialist. Clinical performance, time consumption in simulated scenarios, correlation between framework training and nontechnical skills performance were assessed. **Results**: The average percentages of CPR completed in the Group 1 (G1) with framework education and the Group 2 (G2) were 85% (SEM: 6.20%) and 53% (SEM: 5.77%) respectively ($P < 0.001$). And the average percentages of TI completed in G2 with framework education was 87% (SEM: 3.96%), higher than G1 (50%, SEM: 5.64%) ($P < 0.001$). As for time consumption, the mean time to complete CPR in groups with framework education was shorter than in groups without framework education ($P < 0.005$). Similarly, the mean time to complete TI in groups with framework education was shorter than in groups without framework education ($P < 0.005$). Further, there was a significant correlation between framework training and communication in simulated scenarios. **Conclusion**: The framework provides the whole procedure of the task to every participant. Structured framework education can improve

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nontechnical skills as well as technical skills of doctors and nurses. Further, researches should be conducted to evaluate the clinical performance and correlation between technical skills and nontechnical skills in cardiothoracic training.

Keywords

CPR, Education, Framework, Nontechnical Skills

1. Introduction

Cardiothoracic residents may encounter life-threatening emergency from the first day they start training in hospital. Residents learn technical and clinical skills from various emergent cases. However, promoting patients' safety is a challenge at the forefront of cardiothoracic resident training. Recently, the American college of Surgeons developed a simulation-based education program to enhance patient safety for surgical training through technologies and practice [1]. This program considered simulation training as an important part of educational process in cardiac surgeon. Besides, simulation-based education promotes meaningful experiences and enhances residents' abilities of crisis management, decision making and teamwork [2].

Dexterity and deliberative practice are of great importance in cardiac emergency as well as cardiac surgery. Many training programs and simulators based on cardiac surgery have been developed since the call for educational reform in 2008 [3], while the cardiac emergency in intensive care unit (ICU) cannot attract people's attention. Proficient technology, skilled cooperation and critical thinking are closely associated with patient's prognosis. To conduct accurate and timely treatment for patient in cardiac emergent case, nontechnical skills such as communication and teamwork become increasingly essential. Cardiac residents and ICU nurses must be very familiar with the process of emergent treatment. Thus, the standard structured framework plays a critical role in shortening operation time and smoothen the procedure.

To promote the clinical skills of the participants, the Simulation-Based Training Program (SBT Program) has been launched from 2017 in Naval Medical University in China, as an important component of the education reform. In this settings, simulation-based clinical skills training, mainly based on structured frameworks, has been applied for residents and nurses. The aim of this study was to assess the role of structured framework in simulated emergency accident training for cardiac residents and the relationship between structured framework and technical or nontechnical skills performance.

2. Methodology

2.1. Simulated Training and Video Review

All the residents, attending surgeons and ICU nurses included in this study were

from Changzheng Hospital. The team was composed of one cardiac resident, one attending surgeon and two ICU nurses. There were 24 teams dividing into two groups by lot: the Group 1 (G1) and the Group 2 (G2). Each group has 12 teams. We conducted the simulation training in two separate semesters: the first semester was from January, 2017 to April, 2017 and the second was from August, 2017 to November, 2017.

Two high-fidelity cardiac emergent scenarios were included in our simulation training. We created two different emergent scenarios: the first involved a cardiac arrest occurred in a postoperative patient. In this case, cardiopulmonary resuscitation (CPR) is required to save patient's life. The second involved an acute respiratory failure from a patient with severe lung infection. In this case, tracheal intubation (TI) is recommended to perform in patient to keep breathing. Before the simulation, an introduction of cardiac emergency was given to all the residents, attending surgeons and emergency department nurses through a lecture. In the first semester, G1 completed a three-hour interactive education about the framework applied in CPR, while G2 received a two-hour framework training about TI. In the second semester, G1 received the framework training about TI and G2 completed interactive education about framework in CPR (**Figure 1**).

In the first case, the doctors and nurses were asked to perform CPR based on American Heart Association (AHA) guidelines during cardiac arrest occurred in ICU suddenly [4]. In the second case, the doctors and nurses were asked to perform TI based on the guideline established by *the New England Journal of Medicine* [5]. The participants conducted these two cases consecutively. Simulations used the Emergency Care Simulator (ECS, METI, Sarasota, Florida), which can provide operating conditions for both CPR and TI procedures. All the procedures were recorded by cameras. One cardiologist and one emergency medicine specialist reviewed all the videos to evaluate the trainers' performance independently.

2.2. Structured Framework

For each case, a comprehensive structured framework was taught to residents, attending surgeons and ICU nurses. In every section, doctors and nurses are working together based on framework or their experience. In CPR scenario, the procedure is divided into 3 sections (**Figure 2**). In Section 1, when cardiac arrest occurs in ICU, doctors or nurses should evaluate patient immediately. Then, in Section 2, doctors and nurses should put the patient in supine position, establish venous access and monitor patient's vital signs. If the patient encounters ventricular fibrillation or pulseless ventricular tachycardia, defibrillation is required for the patient immediately. And then, CPR cycles are needed. In Section 3, vasoactive drugs are used to support patient's heart function. In TI scenario, the procedure is also divided into 3 sections (**Figure 3**). In the first section, doctors or nurses should evaluate the patient's airway and oral condition. And put the patient in supine position, choose the tube for TI. Before TI, vital sign monitoring is required. In Section 2, doctor should put in the laryngoscope before TI. At

last, mechanical ventilation is carried on.

2.3. Clinical Scoring

To assess the effect of framework on simulated cardiac emergency, we evaluate the percentage of completed task, the mean time of completed the procedure and the score of scenarios. The score of scenarios was evaluated by cardiologist and emergency medicine specialist during video review. If there is any discrepancy between cardiologist and emergency medicine specialist, the disagreement was discussed in the final evaluating meeting by all the cardiologists and emergency medicine specialists. As for nontechnical skills, there are 4 categories including situation awareness, decision making, communication and resource management. Every category has a scale of 1 to 10. The assessment of nontechnical skills focuses on the entire team rather than on single individual. The progression of framework during simulated scenarios was assessed mainly based on nontechnical skills.

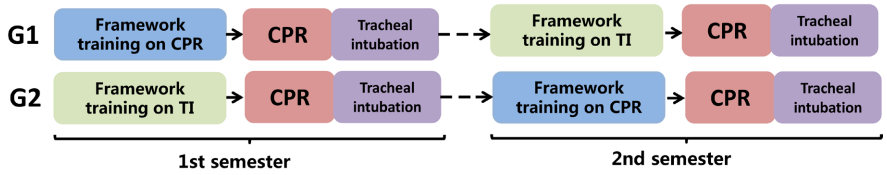

Figure 1. The framework training flow of cardiopulmonary resuscitation (CPR) and tracheal intubation (TI) in two groups.

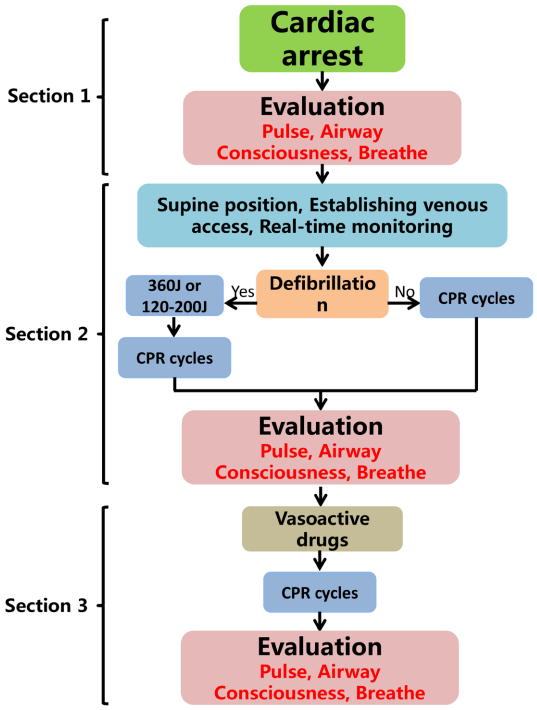

Figure 2. The three sections of procedure flow of cardiopulmonary resuscitation (CPR).

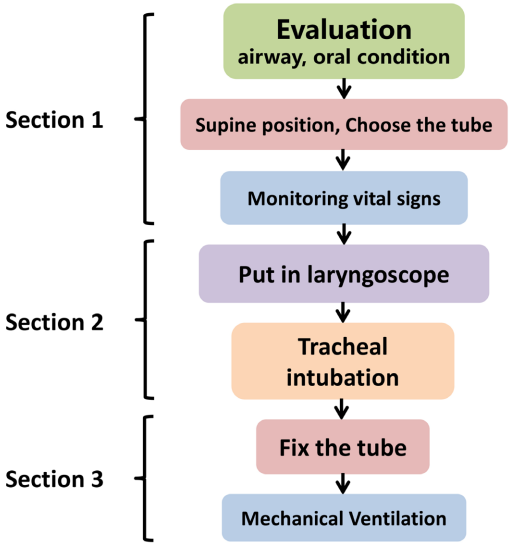

Figure 3. The three sections of procedure flow of tracheal intubation (TI).

2.4. Statistics

The percentage of critical tasks completed was calculated. The mean time of CPR and tracheal intubation was showed as mean ± SEM (min). The score of scenarios for each team was evaluated by student t test. All the statistical analysis was performed by SPSS 20.0 (SPSS, Inc.; Chicago, IL). $P < 0.05$ was considered as statistically significant.

3. Results

3.1. Clinical Performance

In every scenario, the percentage of tasks completed in two semesters was assessed. In the first semester, G1 received a three-hour interactive education about the framework applied in CPR, and G2 received a two-hour framework training about TI. The average percentages of CPR completed in G1 and G2 were 85% (SEM: 6.20%) and 53% (SEM: 5.77%) respectively. The completed percentage of CPR in G1 was higher than in G2 ($P < 0.001$). The average percentages of TI completed in G2 was 87% (SEM: 3.96%), higher than G1 (50%, SEM: 5.64%) ($P < 0.001$). In the second semester, G1 received a two-hour framework training about TI, and G2 received a three-hour interactive education about the framework applied in CPR. The average percentages of CPR completed in G2 was 87% (SEM: 5.36%), compared with G1 (79%, SEM: 5.82%) ($P < 0.001$). The average percentages of TI completed in G1 and G2 were 85% (SEM: 3.69%) and 66% (SEM: 8.48%) ($P < 0.001$). The result of clinical performance was show in **Figure 4**.

3.2. Time of Framework during Simulated Scenarios

Time consumption is calculated to assess the effect of framework in simulated

scenarios. In the first semester, the mean time to complete CPR in G1 was 488 seconds, shorter than in G2 (637s) ($P = 0.025$). The mean time to complete TI in G2 was 464s, shorter than in G1 (579s) ($P = 0.003$). In the second semester, the mean time to complete CPR in G2 was 517s, shorter than in G1 (550s) (P = 0.076). The mean time to complete TI in G1 was 485s, shorter than in G2 (534s) ($P = 0.024$). The result of time consumption of CPR and TI was show in Figure 5.

3.3. Correlation between Framework Training and Nontechnical Skill Performance

The correlation between framework training and nontechnical skill performance was analyzed using combined data from two semesters. We analyzed the correlation between framework training and nontechnical skill performance by four categories: situation awareness, decision making, communication and resource management (Table 1). There was a significant correlation between framework training and communication in simulated scenarios. However, there was no significant correlation for situation awareness, decision making and resource management.

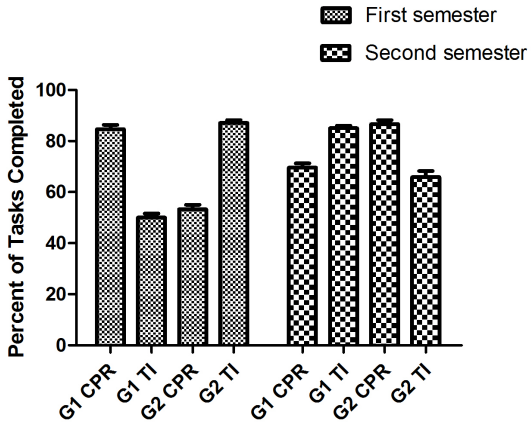

Figure 4. The average percentages of two tasks in two groups.

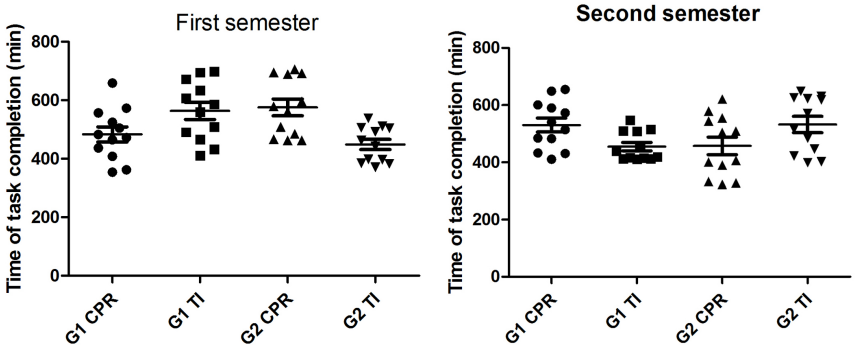

Figure 5. The time consumption of two groups to complete the cardiopulmonary resuscitation (CPR) and tracheal intubation (TI) tasks.

Table 1. Correlation between framework training and nontechnical skill performance after framework training.

	G1 CPR		G1 TI		G2 CPR		G2 TI	
	Correlation coefficient	*P* value	Correlation coefficient	*P* value	Correlation coefficient	*P* value	Correlation coefficient	*P* value
Situation awareness	0.372	0.066	0.286	0.091	0.282	0.108	0.195	0.196
Decision making	0.256	0.137	0.302	0.067	0.362	0.071	0.307	0.064
Communication	0.432	0.012	0.416	0.023	0.408	0.034	0.298	0.041
Resource management	0.275	0.089	0.354	0.074	0.122	0.298	0.248	0.156

CPR, cardiopulmonary resuscitation; TI, tracheal intubation.

4. Discussion

Our study performed a preliminary analysis to assess the effect of framework in simulated cardiac emergency for cardiothoracic training. We evaluated the effect of framework by three dimensions: clinical performance, time consumption and correlation between framework training and technical skill performance. The average percentage of tasks completed in teams which received framework education was higher than the ones which did not receive training in both CPR and TI simulated scenarios. What is more, the mean time to complete CPR and TI in framework trained teams was shorter than non-trained teams. Further, to investigate the correlation between framework training and nontechnical skills performance, we analyzed it by four categories: situation awareness, decision making, communication and resource management. The result showed that there was a significant correlation between framework training and communication in simulated scenarios.

Cardiac arrest is a common public health problem after heart surgery. High-quality CPR contributes to patient's prognosis and recovery of nervous system function after cardiac arrest [6]. Even with standard training, health care providers cannot perform CPR during cardiac arrest according to established American Heart Association (AHA) guidelines [7]. Emergency airway management is another important issue to avoid life-threatening hypoxia for patient in ICU. The time to intubation is associated with patient's life. Time constraints, competing paperwork and poor engagement are the main barriers to Implementation of TI [8]. Thus, simulated training is necessity for doctor and nurse to perform a high-quality TI during cardiac emergency incident in ICU.

Technical and nontechnical skills are equally essential to effectively as a team in cardiac emergencies. Previous studies showed that teamwork training can reduce errors to improve patient safety [9] [10]. Nontechnical skills including communication, situational awareness, managing workload and decision making are important factors to reduce error in the emergency department [11]. However, there is limited evidence to assess these factors' effect after framework training to improve patient safety and reduce error in cardiac emergency incidence. In this study, we created a framework based on four categories to improve the performance of teamwork and evaluate the relationship between framework

training and nontechnical skill performance.

Among these nontechnical skills, situation awareness requires the doctor or nurse can pick up cues that may need medical action in a sudden incidence and relay the massage to the whole team [11]. Besides, doctor and nurse should consider the big picture of patient care in emergency to recover errors [12]. In another study, lack of situation awareness, such as insufficient patient monitoring is a critical incident to cardiac arrest [13]. Thus, doctor and nurse should not miss any critical illness and keep alert in the ICU, especially for patient who is at high risk. Clinical supervision is considered to be important for improving clinical care and enhancing professional confidence [14]. Decision making is a critical thinking process closely related to professional knowledge and clinical experience. Decision making has association with surgical adverse events in hospitalized patients [15]. Previous studies showed decision making plays increasingly important role in cardiac patients care. Shared decision-making could improve the quality and experience of care in cardiac patients [16]. Decision making is of importance in out of hospital cardiac arrest as well as emergency department. Brandling et al conducted a study on UK Emergency Medical Services and found that protocol, guidance and confidence could improve the patient outcomes [17]. This research emphasized the effect of protocol and guidance on cardiac arrest. However, in our study, there was no significant difference between decision making and framework training. Communication is a critical nontechnical skill to perform high-quality resuscitation. Failure to communicate effectively may lead to misunderstanding, resulting in adverse events and poor patient prognosis. Our study showed that communication performance was related to framework training. Communication between doctor and nurse is an essential component of patient safety and error reduction [18]. Resource management is one of the five categories in nontechnical skills (NOTECHS) scale for trauma resuscitations in teamwork [19]. Resource management skill is a progressive ability and it can be improved by simulated training. In our study, the percentage of task completed increased in educated groups, compared to non-educated groups. After framework training, team members clearly filled roles and performed effectively in the simulated tasks.

Technical skills and nontechnical skills are important factors to improve patient safety and reduce errors. Framework training is a practical approach that allows our study performed a preliminary analysis to assess the effect of framework in simulated cardiac emergency for cardiothoracic training. We evaluated the effect of framework by three dimensions: clinical performance, Time consumption and correlation between framework training and nontechnical skill performance. The average percentage of task completed in teams which received framework education was higher than the ones which did not receive training in both CPR and TI simulated scenarios. What is more, the mean time to complete CPR and TI in framework trained teams was shorter than non-trained teams. Further, to investigate the correlation between framework training and nontech-

nical skill performance, we analyzed it by four categories: situation awareness, decision making, communication and resource management. The result showed that there was a significant correlation between communication and framework training in simulated scenarios.

Our study had several limitations. First of all, we compared the performance of different teams, of which results might be affected by other factors, such as the baseline characteristics of different grades. Second, the sample size in our study should be increased for more accurate data analysis. Last, since the education program was only initiated in recent years, the trainings required further improvement and enhancement.

5. Conclusion

The framework provides the whole procedure of the task to every participant in cardiothoracic training of simulated cardiac emergency. Structured framework education can improve nontechnical skills as well as technical skills of doctors and nurses. Further, researches should be conducted to evaluate the clinical performance and correlation between technical skills and nontechnical skills in cardiothoracic training.

Ethics Approval and Consent to Participate

This study was approved by the Committee on Ethics of Biomedicine of the Naval Medical University and was exempt from medical ethical review. Participants received written information and were asked to give written informed consent.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Gardner, A.K., Lachapelle, K., Pozner, C.N., *et al.* (2015) Expanding Simulation-Based Education through Institution-Wide Initiatives: A Blueprint for Success. *Surgery*, **158**, 1403-1407. https://doi.org/10.1016/j.surg.2015.03.040

[2] Raemer, D.B. (2009) Simulation in Cardiothoracic Surgery: A Paradigm Shift in Education? *The Journal of Thoracic and Cardiovascular Surgery*, **138**, 1065-1066. https://doi.org/10.1016/j.jtcvs.2009.07.056

[3] Chitwood Jr., W.R., Spray, T.L., Feins, R.H., *et al.* (2008) Mission Critical: Thoracic Surgery Education Reform. *The Journal of Thoracic and Cardiovascular Surgery*,

136, 812-813. https://doi.org/10.1016/j.jtcvs.2008.08.012

[4] Hauk, L. (2016) AHA Updates Guidelines for CPR and Emergency Cardiovascular Care. *American Family Physician*, **93**, 791-797.

[5] Kabrhel, C., Thomsen, T.W., Setnik, G.S., *et al.* (2007) Videos in Clinical Medicine. Orotracheal Intubation. *The New England Journal of Medicine*, **356**, e15. https://doi.org/10.1056/NEJMvcm063574

[6] Cheskes, S., Schmicker, R.H., Christenson, J., *et al.* (2011) Perishock Pause: An Independent Predictor of Survival from Out-of-Hospital Shockable Cardiac Arrest. *Circulation*, **124**, 58-66. https://doi.org/10.1161/CIRCULATIONAHA.110.010736

[7] Meaney, P.A., Bobrow, B.J., Mancini, M.E., *et al.* (2013) Cardiopulmonary Resuscitation Quality: Improving Cardiac Resuscitation Outcomes Both Inside and Outside the Hospital: A Consensus Statement from the American Heart Association. *Circulation*, **128**, 417-435. https://doi.org/10.1161/CIR.0b013e31829d8654

[8] Finn Davis, K., Napolitano, N., Li, S., *et al.* (2017) Promoters and Barriers to Implementation of Tracheal Intubation Airway Safety Bundle: A Mixed-Method Analysis. *Pediatric Critical Care Medicine: A Journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies*, **18**, 965-972. https://doi.org/10.1097/PCC.0000000000001251

[9] Grogan, E.L., Stiles, R.A., France, D.J., *et al.* (2004) The Impact of Aviation-Based Teamwork Training on the Attitudes of Health-Care Professionals. *Journal of the American College of Surgeons*, **199**, 843-848. https://doi.org/10.1016/j.jamcollsurg.2004.08.021

[10] Reader, T.W., Flin, R., Mearns, K., *et al.* (2009) Developing a Team Performance Framework for the Intensive Care Unit. *Critical Care Medicine*, **37**, 1787-1793. https://doi.org/10.1097/CCM.0b013e31819f0451

[11] Flowerdew, L., Brown, R., Vincent, C., *et al.* (2012) Identifying Nontechnical Skills Associated with Safety in the Emergency Department: A Scoping Review of the Literature. *Annals of Emergency Medicine*, **59**, 386-394. https://doi.org/10.1016/j.annemergmed.2011.11.021

[12] Henneman, E.A., Blank, F.S., Gawlinski, A., *et al.* (2006) Strategies Used by Nurses to Recover Medical Errors in an Academic Emergency Department Setting. *Applied Nursing Research*, **19**, 70-77. https://doi.org/10.1016/j.apnr.2005.05.006

[13] Andersen, P.O., Maaloe, R. and Andersen, H.B. (2010) Critical Incidents Related to Cardiac Arrests Reported to the Danish Patient Safety Database. *Resuscitation*, **81**, 312-316. https://doi.org/10.1016/j.resuscitation.2009.10.018

[14] Kilroy, D.A. (2006) Clinical Supervision in the Emergency Department: A Critical Incident Study. *Emergency Medicine Journal*, **23**, 105-108. https://doi.org/10.1136/emj.2004.022913

[15] Leape, L.L., Brennan, T.A., Laird, N., *et al.* (1991) The Nature of Adverse Events in Hospitalized Patients. Results of the Harvard Medical Practice Study II. *The New England Journal of Medicine*, **324**, 377-384. https://doi.org/10.1056/NEJM199102073240605

[16] Probst, M.A., Noseworthy, P.A., Brito, J.P., *et al.* (2018) Shared Decision-Making as the Future of Emergency Cardiology. *Canadian Journal of Cardiology*, **34**, 117-124. https://doi.org/10.1016/j.cjca.2017.09.014

[17] Brandling, J., Kirby, K., Black, S., *et al.* (2017) Emergency Medical Service Provider Decision-Making in out of Hospital Cardiac Arrest: An Exploratory Study. *BMC Emergency Medicine*, **17**, Article No. 24. https://doi.org/10.1186/s12873-017-0136-3

[18] Munroe, B., Curtis, K., Murphy, M., *et al.* (2016) A Structured Framework Improves

Clinical Patient Assessment and Nontechnical Skills of Early Career Emergency Nurses: A Pre-Post Study Using Full Immersion Simulation. *Journal of Clinical Nursing*, **25**, 2262-2274. https://doi.org/10.1111/jocn.13284

[19] Steinemann, S., Berg, B., DiTullio, A., *et al.* (2012) Assessing Teamwork in the Trauma Bay: Introduction of a Modified "NOTECHS" Scale for Trauma. *American Journal of Surgery*, **203**, 69-75. https://doi.org/10.1016/j.amjsurg.2011.08.004