Tele-mentored damage control and emergency trauma surgery: A feasibility study using live-tissue models

Abstract:

Background: Damage control and emergency surgical procedures in trauma have the potential to save lives. They may occasionally not be performed due to clinician inexperience or lack of comfort and knowledge.

Methods: Canadian Armed Forces non-surgeon Medical Officers (MOs) participated in a live tissue training exercise. They received tele-mentoring assistance using a secure video-conferencing application on a smartphone/tablet platform. Feasibility of tele-mentored surgery was studied by measuring their effectiveness at completing a set series of tasks in this pilot study. Additionally, their comfort and willingness to perform studied procedures was gauged using pre- and post-study surveys.

Results: With no pre-procedural teaching, participants were able to complete surgical airway, chest tube insertion and resuscitative thoracotomy with 100% effectiveness with no noted complications. Comfort level and willingness to perform these procedures were improved with tele-mentoring. Participants felt that tele-mentored surgery would benefit their performance of resuscitative thoracotomy most.

Conclusion: The use of tele-mentored surgery to assist non-surgeon clinicians in the performance of damage control and emergency surgical procedures is feasible. More study is required to validate its effectiveness.

Keywords: Tele-mentored surgery, Life-Saving-Interventions, telemedicine, combat injury
Background

Damage control and emergency surgical procedures for trauma are potential life-saving maneuvers that often are not completed due to first responder or primary care provider’s lack of knowledge, experience or comfort. Tele-mentored surgical skills have been examined in several settings and demonstrated encouraging results. We sought to examine the feasibility of tele-mentoring non-surgeon operators in effectively performing some of the life-saving interventions as described by Gerhardt et al. such as surgical airway and chest tube insertion. Given the possible correlation between injury-to-procedure time and survival in emergency thoracotomy, this procedure was also included in the study. We also examined whether tele-mentoring improved non-surgeon confidence and increased willingness to perform these tasks in an otherwise unsupported setting.

Methods

Tele-mentored emergency trauma skills were studied using a porcine live tissue (LT) model. Ethics approval was obtained through our institutional Ethics Review Board and all animal research protocols were followed in accordance with our research centre standing orders. Participants were drawn from a pool of candidates on the Advanced Military Trauma Resuscitation Program (AMTRP) course. AMTRP candidates consist of several military clinicians, including non-surgeon medical officers (MOs). Only non-surgeon MOs were asked to be participants given the limited number of live tissue models. Participants received no pre-study training in order to closely mimic an emergency situation that requires performing an unfamiliar procedure or one that may have suffered the effects of skill fade due to a prolonged interval since last practiced. They were briefed on the nature of the study on arrival at the lab, provided informed consent, then performed the described procedures with tele-mentored assistance.

The mentoring surgeon (PD) and operators communicated using iPad2 tablets running Reacts Lite™, a secure videoconferencing app (v.2.4.5.10, Innovative Imaging Technologies, Inc., Montreal, QC). This allowed the mentor real-time supervision capability and the ability to guide the procedure using verbal instructions along with a virtual pointer overlaid on the surgical field.

Participants

Two of our participants were FRCPC (5-year training program) emergency physicians while the other two were general practitioner/family physicians, one with the one-year emergency medicine designation; technical difficulties (no signal was available in his portion of the laboratory) were experienced with the latter and he was therefore unable to participate. He was not included in the survey as
he was not able to appreciate the effects of tele-mentoring. One physician assistant was also present for one of the MO’s procedures. He was in a strictly observational role and therefore did complete the surveys.

Data collection

Three of the authors (PD, NG, MH) determined a set of criteria for all tele-mentored tasks. Certain of the criteria were considered critical and are described in Table 1. Scoring was recorded as a pass/fail grade based on a percentage of 50% or greater and all critical criterion being completed. Participants also conducted a pre- and post-procedure survey to gauge confidence and willingness to perform these tasks independently or with tele-mentoring using a Likert-score questionnaire.

Results

Effective completion of tasks

After completion of each task, specimens were examined by PD to evaluate success of the procedure. All three observed participants completed their respective tasks successfully, meeting 100% of designated criteria, including all those deemed critical. These results are listed in Table 2. No complications were observed.

Comfort and willingness survey

Participants (MOs) were asked to complete a series of Likert scale surveys to gauge the perceived benefit of tele-mentoring in these tasks. Pooled data is listed in Table 3. Notably, there is modest improvement in their comfort level pre- and post-study. This could be a result of simply completing one procedure in a live-tissue lab. There appears to be more pronounced improvement in willingness to perform a resuscitative thoracotomy with tele-mentoring, likely due to the degree of difficulty and rarity of this procedure. Less benefit in terms of comfort and willingness were noted with surgical airway and chest tube insertion. Despite these results, all participants rated the benefit of tele-mentoring very highly with the mean score being 5/5 for all three procedures.

Discussion

Canadian Armed Forces (CAF) non-surgeon medical officers frequently deploy to remote locations. They may be employed as primary care providers working independently or within a larger facility with surgical resources. During deployed operations in Afghanistan and Iraq, resuscitative thoracotomy showed most beneficial in patients losing vital signs within the emergency department or following admission to hospital. One could extrapolate that the critical factor was time
from loss of vital signs to intervention, and that pushing the procedural capability forward (in the military setting) or peripherally (in the civilian setting) could increase survival. Chest tube insertion and surgical airway are skills taught on ATLS but can easily be associated with diminished knowledge and confidence if not frequently used. Trained surgeons are a finite resource that are difficult to pre-position everywhere and it is impossible to predict the need for surgical intervention, particularly in low-volume environments such as low-intensity combat zones or rural settings. Non-surgeon clinicians tele-mentored by surgeons might be able to bridge the gap in emergent situations where transfer to a higher-level centre cannot be done sufficiently quickly.

Although further study is needed to validate the effectiveness of tele-mentored surgery, our results suggest that tasks can be adequately completed by non-surgeons with appropriate tele-mentoring. It also increased both their willingness and comfort level with completing unfamiliar tasks, particularly with resuscitative thoracotomy. The participants were fairly experienced (two being FRCPC emergency physicians), which may have increased their pre-study comfort levels with the tasks in question. Perceived benefit of tele-mentoring may have been more pronounced with less experienced clinicians such as PAs and family physicians. The consensus across all participants and the observing PA was that tele-mentoring was very beneficial.

Technology is not likely to be the limiting factor as smartphones or tablets are adequate platforms to run a number of video-conferencing platforms including Reacts Lite™ which was used in this study. Other options could include smart glasses and perhaps to a lesser extent, a head-mounted camera which might preclude the visual feedback conferred by other platforms. A greater obstacle is likely to be broadband width in remote locations, particularly in deployed operations. In fact, within our laboratory with Wifi capability, we failed to communicate with our own participants. If tele-mentoring is embraced as a capability-enhancing function, data transmission will need to be considered in the planning phase.

**Limitations**

The small sample size and the controlled laboratory setting limit the generalizability of this study. A single evaluator of completed tasks and survey reporting are sources of bias.

**Conclusion**

Our study adds to the weight of evidence that tele-mentored surgery can enhance surgical capabilities of non-surgical clinicians. Tele-mentoring appears to be most helpful to the non-surgeon clinician in more difficult and rarely performed procedures such as resuscitative thoracotomy. Several technologic options exist to achieve this but data transmission broadband and operational security when
used in a military setting will likely be the limiting factors in deploying this capability in remote locations.

<table>
<thead>
<tr>
<th>Procedural tasks</th>
<th>ED thoracotomy</th>
<th>Surgical Airway</th>
<th>Chest tube insertion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chest cavity open*</td>
<td>Airway in trachea*</td>
<td>Tube in chest*</td>
</tr>
<tr>
<td>2</td>
<td>Pericardium fully open*</td>
<td>Hemostasis</td>
<td>Last fenestration in chest</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>Tube securely fastened</td>
</tr>
</tbody>
</table>

**Table 1: Assessed task by procedure.** Tasks with an asterisk (*) were deemed critical. A passing grade on the procedure was dependent on all critical tasks being performed and greater than 50% of tasks overall for each procedure.

<table>
<thead>
<tr>
<th>Participant</th>
<th>ED thoracotomy</th>
<th>Surgical Airway</th>
<th>Chest tube insertion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2/2</td>
<td>N/A</td>
<td>3/3</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>3</td>
<td>2/2</td>
<td>2/2</td>
<td>3/3</td>
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<tr>
<td>4</td>
<td>2/2</td>
<td>2/2</td>
<td>3/3</td>
</tr>
</tbody>
</table>

**Table 2: Task-specific scores for each participant.** ED thoracotomy tasks: Chest cavity open*, pericardium fully open*; Surgical Airway tasks: Airway in trachea*, hemostasis; Chest tube tasks: Tube in chest*, Last fenestration in chest, secure.*Critical tasks.
Table 3: Pooled Likert-score (1-5) survey results: Pre-C: Pre-study comfort level with task; Pre-W: Pre-study willingness to perform task independently; Post-C: Post-study comfort level with task; Post-WI: Post-study willingness to perform task independently; Post-WM: Post-study willingness to perform the task with tele-mentoring support; Benefit of TLM: Perceived benefit of tele-mentoring.


ii Talbot M et al, A pilot study of telesurgery for compartment release. Pre-publication.


iv Morrison et al., Resuscitative thoracotomy following wartime injury, J Trauma Acute Care Surg 2013;74(3)825-9.

v Mitchell et al., An 8-year Review of OEF and OIF Resuscitative Thoracotomies, Military Medicine 2015;180(3)33-5.