Hierarchal Task Analysis of Laparoscopic Cholecystectomy

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Abstract
The purpose of this project was to create a hierarchal task analysis (HTA) of a Laparoscopic Cholecystectomy (Lap Chole). Ten Lap Chole’s were recorded and of the ten the most ideal case was chosen and analyzed to create a step-by-step task analysis of a Lap Chole. Two surgical fellows and a resident were asked to critique the HTA in order to increase the accuracy across different surgical styles. This HTA is for the “ideal case” and the surgeons were asked to keep this in mind. We hope to create a systematic way of creating an accurate and comprehensive HTA for any procedure. It was found that Sarker and Cao’s method for creating their HTA was ineffective for the purpose of creating an HTA for an “ideal case”.

1. Introduction
A hierarchal task analysis describes how a task is completed on a step-by-step basis. It can be presented as a diagram or in a table format. For a task analysis a table is most common with columns indicating task number, the verbal task, the plan which indicates which order the sub-tasks should be done, sub-task number, the verbal sub-task, and the recovery, which indicates the procedure should something go wrong during one of the sub-tasks [2]. A hierarchal task analysis is usually presented in a diagram format so the hierarchy is more noticeable [1].

A laparoscopic cholecystectomy is a minimally invasive surgical procedure done by two surgeons to remove the gallbladder from the body. Typically four incisions are made, one for the laparoscope or camera; one for tool to retract or push the liver up to expose the gallbladder; and two incisions for tools to will work to remove the gallbladder from the liver and out of the body.

Two other Lap Chole task analyses were compared with our own, Sarker and Cao. A comparison of the methods they used to create their HTA was done as well as a comparison of the overlap of tasks and sub-tasks. We hope to determine which of the three methods is the most suitable for creating an HTA for the most “ideal case”. Task analyses are created to define a procedure; our HTA takes a laparoscopic cholecystectomy and highlights its most basic tasks. These are the tasks that happen at some point during any Lap Chole despite its complexity, so in other words “the most ideal case”. The motivation behind this is to be able to do a comparison across all Lap Chole’s.
2. Background

Cao created a hierarchal task analysis based off of one video recording of a Lap Chole. Her purpose for creating an HTA was to highlight implications toward surgical training systems [1]. The hierarchal approach gave a systematic method to approach training both in the OR and simulated environment [1].

In order to create her HTA, one individual analyzed the video and steps were created for the procedure. After this was done three expert surgeons independently verified the HTA for its face value. The procedure was broken down into its most surgically meaningful events [1]. Cao’s definition of surgically meaningful events includes the beginning and end of the most fundamental surgical steps. There were a total of 50 tasks and sub-tasks.

Sarker created a task analysis based off of textbooks, articles, papers, Web pages, course manuals, and expert panel discussions [2]. His HTA was meant to be a template for ten surgeons to then personalize to their own surgical style. Sarker wanted the surgeons to self-evaluate their own technical skills. Ten expert surgeons assessed the task analysis and it was changed if any of the surgeons had a differing of opinion with what was written. His task analysis has a total of 70 tasks and sub-tasks. His task analysis went deep enough to describe the tasks and sub-tasks to achieve the goal but not the instrument or technique used to achieve that goal [2].

3. Methods

We created our HTA based on an “ideal case” of a recorded Lap Chole. This ideal case was chosen based on three criteria: lack of motor-based errors, anatomical clarity, and clearly distinguishable tasks. We then used existing task analyses (Cao) to inform the language and general framework of our design. After choosing our ideal case, we broke the operation down into 116 tasks and sub-tasks, which adhered to Cao’s four phases. The division between task and sub-task are defined as follows: tasks are meaningful surgical event’s which could be considered goals of each phase, and sub-tasks are various requirements which are usually met in the completion of a task.

However, we approached this in a different manner than the previous literature. Rather than involving experts later on in the process, we immediately revised our HTA based on their advice. A recorded think-aloud protocol was conducted with three expert surgeons at a Northeastern teaching hospital as they independently went through the task analysis. Each video was transcribed to have a verbal written account of what was said. The task analysis was revised four times before it obtained face validity from each of the three surgeons. Once this was complete, we were able to use this HTA to examine other Lap Chole videos within our sample set. This allowed us to examine where typical deviations occurred.

In order to compare the three HTA’s visually, they were overlaid on top of each other with our HTA as the base. The Gliffy: Online Diagram Software and Flow Chart Software was used to create this overlay. The original HTA was also made on this software. This was done to better understand where the disagreements were.

In our definition of surgery, we specifically looked at the tasks that involve doing a Lap Chole and involve physical actions on or within the patient. Sarker’s 6th
task was omitted because the task was not specific to a Lap Chole. Sarker’s recovery column was not taken into account when doing the comparison.

4. Results
The tasks and sub-tasks were quantified and our HTA was used as the base for all our comparisons. A comprehensive comparison was done as well as a phase-by-phase comparison as per Cao’s major tasks.

Table 1. Illustrates the total number of tasks and sub-tasks.

<table>
<thead>
<tr>
<th></th>
<th>Wong</th>
<th>Sarker</th>
<th>Cao</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tasks</td>
<td>28</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>Sub-tasks</td>
<td>88</td>
<td>55</td>
<td>32</td>
</tr>
<tr>
<td>Total</td>
<td>116</td>
<td>70</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 2. Illustrates the number of tasks per phase for each HTA as well as a comparison with Wong’s HTA.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Wong Task Num.</th>
<th>Sarker Sub-Task Num.</th>
<th>Sarker comparison with Wong</th>
<th>Cao Sub-Task Num.</th>
<th>Cao comparison with Wong</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23</td>
<td>11</td>
<td>.478</td>
<td>11</td>
<td>.478</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>4</td>
<td>.154</td>
<td>7</td>
<td>.269</td>
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<tr>
<td>3</td>
<td>37</td>
<td>12</td>
<td>.324</td>
<td>10</td>
<td>.270</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>11</td>
<td>.698</td>
<td>2</td>
<td>.125</td>
</tr>
<tr>
<td>Total</td>
<td>102</td>
<td>38</td>
<td>.373</td>
<td>30</td>
<td>.294</td>
</tr>
</tbody>
</table>

Table 3. Illustrates the number of non-overlap tasks per phase for each HTA.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Non-overlap Sarker</th>
<th>Non-overlap Cao</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2 shows the phase number and the frequency of overlap for each HTA. For Wong the total number of sub-tasks also includes some high order tasks if overlap existed.

For Cao, over all there was only 29.4% overlap with Wong’s HTA; in other words, only 29.4% of Cao’s HTA matched Wong’s. Phase 1 has 47.8% of the overlap, while Phase 2 and 3 had a similar amount of overlap with 26.9% and 27% overlap, respectively. Phase 4 had the least amount of overlap with only 12.5%. Cao missed many of Wong’s sub-tasks. Cao had the most overlap in Phase 1 because she had the
most number of sub-tasks during that phase. 11 of her 33 sub-tasks were in Phase 1. Phase 2 and 3 both had similar overlap because both phases had similar number of sub-tasks for their respective phases 8 and 9. Phase 4 had the least number of sub-tasks, 2, and accordingly the least overlap.

For Sarker, over all the overlap was 37.3% with Wong’s HTA; in other words 37.3% of Sarker’s HTA overlapped with Wong’s. Phase 1 has 47.8% overlap same as Cao’s. Phase 2 has the least amount of overlap with 15.4%. Phase 3 has 32.4% overlap and Phase 4 had the most overlap unlike Cao with 69.8%. Sarker missed some of Wong’s sub-tasks. Phase 2 only has 5 of the 51 sub-tasks which is why it has the least overlap. Phase 4 has 16 of the 51 overlaps; Phase 3 has 17 of the 51; and Phase 1 has 13 of the 51.

Not all of the tasks overlapped with a task on Wong’s HTA, these are represented in Table 4. These tasks were manually added to the comparison HTA. Cao only had one task that Wong didn’t in Phase 4. Cao has 5 sub-tasks during her Phase 4, 4 of them overlap with a sub-task on Wong’s HTA. The task that doesn’t overlap is ‘Remove tools’. Wong implied that that step was done but never made a sub-task for it. Sarker has a total of 14 tasks that did not overlap with Wong’s. Largest of which occurred during Phase 4 and the second most in Phase 2. In Phase 1, Sarker has two sub-tasks that involve talking to the anesthetist about starting surgery. These tasks are not what we defined as a part of surgery. For Phase 2, there is one sub-task that involves dissecting adhesions to the gallbladder. This task deviates from the ideal case HTA that Wong was working towards. Phase 3 has 5 tasks devoted to doing an operative cholangiogram, which is far from the ideal case scenario. The other task is securing any bleeding from the liver bed before removing the gallbladder from the liver bed. This is a task that Wong was missing from his HTA. Phase 4 has one task that involves placing a drain, which is non-ideal. There are two tasks, which involves talking to scrub nurse to see if all the instruments are accounted for which is not in our definition of surgery. The last two tasks simply go deeper into the closing of the patient than Wong’s HTA went; included cleaning port sites and placing dressing over sites.

One major point of difference between Wong and the other two HTA’s is that Wong has the surgeon clipping the duct then the artery. The other two HTA’s have the artery being clipped first and duct second. This could just be surgeon preference or how the institution teaches the procedure. Another point of difference is that Wong spent a great deal of time properly expressing how the beginning of the procedure would happen. Specifically how the surgeon creates the first incision, open Hassan or Veress needle and included both techniques in his HTA. These are the two techniques that are used to create the first incision at the umbilicus, belly button. Both Sarker and Cao paid very little attention to this part of the operation and made an assumption as to how the first incision will be made. Cao assumed the Veress needle technique and Sarker assumed the open Hassan technique.

5. Conclusion

It can be concluded that Cao’s HTA is very minimalistic since it has the least overlap; Sarker has more overlap but he also has many more non-overlapping tasks. This indicates that his HTA is more comprehensive but was not made for the “ideal”
case. For Cao, Phase 4 seemed to be the source of most conflict while Phase 1 had the most agreement. While for Sarker Phase 2 has the most conflict and Phase 4 was the area of most agreement.

Since Cao’s HTA was devoid of any of the more detailed tasks it is not surprising that she has the least overlap. Sarker was much more detailed with his HTA and so it is also not extraordinary that during one of the most critical phases of the operation, Phase 2, there is the most conflict with Wong’s HTA. The reason behind this is that our entire Phase 2 fits in one of Sarker’s task.

The way in which Sarker came about creating his HTA with textbooks, articles, papers, etc. is appropriate when a comprehensive HTA is required. Cao’s methods were appropriate for creating a simple HTA. Cao was far to brief with her analysis of the procedure and Sarker focused on some of the less important parts of the procedure which make their method systems impractical when creating an HTA for an “ideal” case.

6. Acknowledgement
I would like to thank my mentor, Dr. Helena Mentis, Ph.D. student Yuanyuan Feng, and many other faculty members and students at UMBC for their support and guidance throughout this summer.

7. References
