Research Paper

Proficiency of visual attention for quality of care in endotracheal suctioning

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ABSTRACT

Endotracheal suctioning is a complicated, invasive and multitask procedure that requires immediate and accurate responses to patients with airway obstruction. However, few studies focused on expert nurses’ proficiency during endotracheal suctioning. The aim of this research was to measure experienced nurses’ proficiency by eye trajectory analysis. The hypothesis is that experienced nurses will demonstrate effective eye movements which contribute to the quality of nursing techniques. This study was conducted in a clinical simulation laboratory in a large metropolitan university. Eleven experienced nurses from three institutions and nine nursing students from a university were recruited in this study. Data were collected by a head-mount camera and a binocular camera while participants performed endotracheal suctioning on a simulator manikin. Eye movements of nursing students seemed very slow in comparison to experienced nurses, but their cognitive activity was high from the result of their eye trajectory. Nurses hardly watched items closely. Nursing students’ strategy in skill acquisition simplified the tasks into small parts, thus, they require more time to perform. Proficiency of experienced nurses in endotracheal suctioning was partially unveiled in contrast with eye trajectory of nursing students. The establishment of educational tactics to enhance students’ skill acquisition, including debriefing, part learning and discrepancy of hand-eye coordination are studies to be embarked on.

Keywords: Eye trajectory analysis, skill acquisition strategy, proficiency development, tacit knowledge.

INTRODUCTION

Endotracheal suctioning is a complicated, invasive, multitask procedure that requires immediate and accurate responses to patients with airway obstruction. However, few studies have focused on expert nurses’ proficiency during endotracheal suctioning.

Since a notion of “tacit knowledge (Polanyi, 1966)” has been widely recognized, visualization of dexterity and applications to educational arena were regarded as admirable challenge among nursing faculties. One of the common teaching style in a clinical setting used to be an apprentice system (Agbedia and Ogbe, 2014; Kermansaravi et al, 2015) that experienced nurses use in demonstrating their skills for novice nurses to make them obtain their maneuvers and its significance. With inconsistent learning opportunities, novice nurses manage to acquire adequate motion of their bodies as effective tools for nursing with accurate professional knowledge (Forbes, 2010, 2011). Under such circumstances, limitation of learning by doing hospital-based apprenticeship training might be “work readiness” of graduates (Hegney et al, 2013), that causes the difficulty of building trust relationships between patients. Patients’ anxiety whether students make any mistakes and lower nurse staffing levels associate with worse patient outcomes (Ball et al, 2013). Current nursing education encounters an antinomy to implement “excellent achievement of students’ clinical practicum” and “safe environment for patients” under the conventional system.

Recently, eye mark recorder usage as a pedagogic evaluation is wide-spread in nursing, that is, to identify gaps in nursing students’ contextual knowledge during
medication administration (Amster et al., 2015), to inform students' as a debriefing process after a simulation experience (Henneman et al., 2014; O'Meara et al., 2015), to reveal experienced nurses' risk prediction (Henneman et al., 2014; Nishimura, 2016) and to verbalize characteristics of attention (Daikoku and Saito, 2017).

Hybrid models, using eye-tracking devices and observing visual processing that will support the determination of the most efficient methods in nursing pedagogy was suggested (Forbes, 2016). Although, there are limitations such as correctness of gaze capture and cost performance, eye tracking has the potential to enhance debriefing and educational outcomes (Browning et al., 2016; Terai et al., 2017).

Aim

The aim of this research was to measure experienced nurses' proficiency during endotracheal suctioning for conversion of skills from implicit to explicit knowledge through eye trajectory analysis. We hypothesized that experienced nurses will demonstrate more efficient and effective eye movements than nursing students, which is a foundation of the quality of nursing care.

MATERIALS AND METHODS

This is a pilot study with an observational design.

Setting

This study was conducted in a simulation laboratory in a large metropolitan university.

Sample

Eleven experienced nurses from three institutions and nine nursing students from a university were recruited in this study through a bulletin board of the university. Sample size was decided following previous studies (Seya et al., 2008; Ishibashi et al., 2010; Mori et al., 2013).

The inclusion criteria for experienced nurses were registered nurses who have more than three years of clinical experience at any wards. For nursing students, the inclusion criteria were the third year baccalaurate students just after basic lecture about suctioning with no experience of suctioning in any situation including their clinical practicums. The absence of visual abnormalities was checked in both groups. The exclusion criteria in both groups were: 1) unable to chase a mark for calibration without glasses; 2) wearing colour contact lenses; 3) excessive periorbital puffiness that hides pupils from camera lens; and 4) the colour of iris was black.

Participants' eye trajectory was measured by EMR-9 version 2.61 model ST-725 (NAC image Technology Inc.). Participants wore a cap with a camera for background view recording and binocular cameras for calculating eye trajectory. The sampling rate was 60 Hz/s. The lens field was 60°. EMR-dFactory version 2.7.0 was used for data analysis. Gaze was defined as more than 100 ms and less than 2.00° following previous study (Endo and Kohama, 2012) and gaze item count, gaze duration were compared in two groups.

The target task to evaluate attention shift was throughout the process of endotracheal suctioning on simulator manikin from a motion of "putting disposable gloves on" to "disposing gloves". The manikin has a tracheal tube with tracheotomy. A series of suctioning procedure was divided into six phases; 1) putting disposable gloves, 2) catheter preparation, 3) inserting a catheter, 4) putting a catheter in order, 5) hanging a suctioning tube and 6) removing gloves. A mock-up connector for ventilator was prepared on a tip of the tracheal tube. No biological reflections of the manikin were shown for the participants. Each participant performed the experiment twice and the best trial was used for analysis.

The protocol was approved by the ethical committee in one of the researcher's affiliation (no. 13-2). Written agreement forms were received after explanation for research co-operation forms were received after explanation for research co-operation prior to commencing of research.

RESULTS

The median age was 29 years for the nurse group and 21 years for the student group. The mean performance time of the nurse group and the student group were 99.3±18.6 s and 167.8±34.28 s, respectively. The 11th nurse for the minimum performance time (79.3 s) and the 1st student for the maximum performance time (229.0 s) were chosen for analysis.

Table 1 is the gaze item count and gaze fixation of nursing student (upper) and a nurse (lower). Maximum gaze count was for a student looking at a suctioning catheter (26 times). The student spent about 50.3 s to deal with a suctioning catheter, while the nurse looked at a catheter only about 16.5 s throughout the procedure. The second longest gaze time was on suction tube for the student (32.2 s). For the nurse, it was only 5.1 s in total. On the other hand, the nurse observed a patient for about 5.1 s; however, it was about 3.6 s for the student. The remarkable difference in proficiency was observation of pulse oximeter. The student did not give a glance on it, but the nurse paid attention about 4 times (about 2.3 s) during a procedure.

Figure 1 shows the gaze items and gaze fixation in six phases. One horizontal cell signifies 20 s. The eye trajectory of the student was generally dull. The student concentrated on the gloves while wearing them. The nurse, however, watched a catheter vaso, water vaso, succion machine,
Table 1: Characteristics of gaze count and duration.

<table>
<thead>
<tr>
<th>Item name</th>
<th>Gaze count</th>
<th>Total gaze time</th>
<th>Gaze time count/ Total data count</th>
<th>Gaze count/ Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheter vase</td>
<td>16</td>
<td>8.375</td>
<td>0.041376</td>
<td>0.002479</td>
</tr>
<tr>
<td>Water vase</td>
<td>10</td>
<td>12.145</td>
<td>0.057958</td>
<td>0.001550</td>
</tr>
<tr>
<td>Suction apparatus</td>
<td>14</td>
<td>17.017</td>
<td>0.081203</td>
<td>0.002170</td>
</tr>
<tr>
<td>Suction tube</td>
<td>24</td>
<td>32.232</td>
<td>0.153417</td>
<td>0.003719</td>
</tr>
<tr>
<td>Patient</td>
<td>8</td>
<td>3.604</td>
<td>0.017976</td>
<td>0.001240</td>
</tr>
<tr>
<td>Tracheal tube</td>
<td>6</td>
<td>19.052</td>
<td>0.089416</td>
<td>0.000930</td>
</tr>
<tr>
<td>Pulse oximeter</td>
<td>0</td>
<td>0.000</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
<tr>
<td>Catheter</td>
<td>26</td>
<td>50.284</td>
<td>0.237564</td>
<td>0.004029</td>
</tr>
<tr>
<td>Connector</td>
<td>9</td>
<td>3.871</td>
<td>0.018441</td>
<td>0.000465</td>
</tr>
<tr>
<td>Gloves</td>
<td>4</td>
<td>25.359</td>
<td>0.118395</td>
<td>0.000620</td>
</tr>
<tr>
<td>Glove box</td>
<td>4</td>
<td>7.307</td>
<td>0.034558</td>
<td>0.000620</td>
</tr>
<tr>
<td>Alcohol cotton</td>
<td>9</td>
<td>16.016</td>
<td>0.075779</td>
<td>0.001395</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>0.000</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
<tr>
<td>Error</td>
<td>0</td>
<td>0.000</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
</tbody>
</table>

suction tube and a connector on the tracheal tube as well as, gloves. The nurse's timings of checking pulse oximeter were: just before inserting a suctioning catheter, after suctioning sputum, while wiping a catheter and after disposing gloves.

Figure 2 shows sample pictures for nurse's eye trajectory during the six phases. Nurses hardly watched items closely and once held them in one hand. As soon as distilled water is absorbed with a catheter in phase 2, the nurse takes off a connector and turned direction towards a patient model's face. At the moment of touching the connector, almost simultaneously the nurse's gaze moved to check patient's facial expression (Picture A). Disconnection of the connector and observation of the patient's face were multitasked. In phase 3, the student's movement from "taking off a connector" to "inserting a catheter in a tracheal tube" was slow and posed with hesitation (24.2 s). During inserting of a catheter, the nurse paid attention on the pulse oximeter (Picture B) and the manikin's face. In phase 4, she observed a patient and a pulse oximeter momentarily while wiping a catheter (Picture C) and immediately washed a catheter. The nursing student did not give a glance to the pulse oximeter through the 6 phases, while the nurse closing a lid of water vase, switched her attention to the suction apparatus (Picture D). After having returned a tube to the suctioning apparatus in phase 5, the nurse switched off quickly with her gloves instantly thrown away. Not surprisingly, no hesitation was in the nurse group. By mastery of skills, nurses could shift their attention from one to the other during an action, whereas nursing students' gaze was fixed on the items to be dealt with.

Figure 3 highlights optic activity by angular velocity and size of participants' right pupil. X-axis is positive when the eye focal point is directed to their right and Y-axis is positive when it goes up. The nursing student's eyes frequently swift up and down throughout the performance to collect information to perform unfamiliar procedure and the size of pupils quickly changed. The size of pupil was slightly larger in the nurse at the beginning of the
Figure 1: Gaze item and gaze fixation in six phases.

Figure 2: Examples of eye trajectory of a nurse.
suctioning procedure, but the angle of light might influence the size of the pupils for both participants.

DISCUSSION

Eye movement of nursing students seemed very slow in comparison to experienced nurses, but their cognitive activity was estimated high from the result of the velocity of pupil diameter change. Attention on a pulse oximeter and a patient’s face might be items of proficiency level. From these results, proficiency of experienced nurses in endotracheal suctioning was partially unveiled in contrast with eye trajectory of nursing students. Experienced nurses demonstrated not just effective eye movements but efficient, which contributed to immediate discovery of a patient’s pneumovascular emergency.

There are several strategies in skill acquisition, a visual search strategy, a memory retrieval strategy, the algorithm based strategy and strategy self-reports (Touron et al., 2010). The endotracheal suctioning techniques, however, require spatial attention. The spatial attention is known as the phenomenon that sense of detection and verbalization increase, being stimulated by positional information in the space. Different from learning by text book, special attention requires numerous practices.

The attention is derived as top-down attention and bottom up attention. Top-down attention is spontaneous
and endogenous, while top-down is goal-directed attention, whereas bottom-up attention is passive and stimulated by stimuli from external environment. There is individual difference in quantity and quality of the attention that a person can distribute. It was said that memory was affected by classification into a schema (Bartlett, 1932) or scaffolding (Jarodzka, 2017) might open a pathway for students’ multitasking. The experts can collect important information feed forward, because they can concentrate their attention to information collection rather than watching their hands to do something. Despite student’s high cognitive activity as the velocity of pupil diameter change, the efficiency of performance was not related. Further researches were required to find out the relationships between the experienced nurses’ size of pupils, level of attention, judgement and maintenance of memory after the procedure.

Conclusions

Nurses demonstrated efficient endotracheal suctioning procedures with their effective eye trajectory in contrast to nursing students. From these results, proficiency of experienced nurses in endotracheal suctioning could be attention on a pulse oximeter and quick movement of eye trajectories. Although, further researches were required to find out the relationships between the experienced nurses’ size of pupils, level of attention, assessment of the phenomenon, judgement and maintenance of memory after the procedure, there seemed possibility of utilization of eye tracking as a skill evaluation tool.

Limitations

The result was extracted from a controlled environment without disturbance during the practice, for example, nurse call and telephone, etc like actual dynamic clinical environment. Simulation learning allows nursing students to perform invasive procedure, however, the patient model used have no function of biological reaction. Trade-off relations of time and the precision of skills, procedural memory (memory of procedural motion) and imitation learning (modeling of imitative learning) were not investigated in this study.

ACKNOWLEDGEMENT

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REFERENCES