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Expert surgeon's quiet eye and slowing down: expertise differences in performance and quiet eye duration during identification and dissection of the recurrent laryngeal nerve

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Abstract

BACKGROUND: Long quiet eye (QE) duration is central to expertise in sports, while cognitive "slowing down" has been identified as a perceptual skill possessed by skilled surgeons. Eye-tracking evidence is lacking about the relationship of QE duration to slowing down in surgeons. The aim of this study was to examine QE duration, hand movement time (MT), fixation location, and fixation duration in highly experienced (HE) and less experienced (LE) surgeons.

METHODS: A mobile eye tracker and camera recorded coupled gaze and hand movements. Performance was quantified by blinded review.

RESULTS: HE surgeons were rated higher than LE surgeons but did not differ in operating time or MT. HE and LE surgeons differed in fixation duration on the ligament of Berry during phases 1 and 2 and QE duration on the recurrent laryngeal nerve in phase 2.

CONCLUSIONS: Long-duration fixation on the ligament of Berry and long-duration QE on the recurrent laryngeal nerve combined with no significant differences in MT provide empirical evidence that HE surgeons cognitively slow down more than LE surgeons during critical phases of the operation.

Recent changes to medical practice and training have produced challenges to the education of new surgeons.[1–3] A greater focus on patient safety and work-hour restrictions limit the educational opportunities of surgical trainees.[4,5] Although simulators offer the opportunity for practice outside of the operating room, there is a need to improve the efficiency of training through the study and use of new educational techniques.

There is a paucity of research showing how the cognitive and motor skills of expert surgeons differ from those of novices. However, the cognitive and motor behaviors of elite athletes have been studied extensively. From this, we know that the control of gaze and attention is pivotal for successful execution of motor skills, whether for a simple task or for complex coordinated movements. An important finding from this literature is the quiet eye (QE), which is

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defined as the final fixation or tracking gaze that is located on a specific location or object in the visuomotor workspace within 3° of the visual angle for ≥100 ms.[6,7] The onset of the QE occurs before a critical movement, and the offset occurs when the gaze deviates off the location or object by >3° for >100 ms. Long-duration QE has been shown to reliably distinguish experts from nonexperts and successful from unsuccessful motor performance.[8–10] The QE is thought to represent the time needed to organize the neural networks underlying the precise control of movements.[11,12]

We adopted Moulton et al's[13] framework of "slowing down" as the theoretical basis of this research. Moulton et al found that expert surgeons transitioned between modes of automatic control and effortful modes in which the surgeons were situationally responsive to difficult or unexpected events. In the latter mode, slowing down represented the surgeon's "cognitive re-focusing and increased attention directed toward a particular task."[14] Moulton et al[14] stressed that slowing down is a cognitive process and does not "describe the speed of the surgeon's hand movements."

Our goal in this study was to empirically determine if slowing down was due to greater cognitive slowing, as would be indicated by longer fixation durations on critical locations, or greater motor slowing, which would be characterized by longer hand movement times. We chose to examine this in a thyroidectomy model because it represents a complex operative skill with limited training opportunities, thus leading to the potential for significant complications.[15] Critical to this operation is the successful identification and preservation of the recurrent laryngeal nerve (RLN), a delicate structure, damage to which may lead to significant postoperative morbidity. For this reason, the standard approach to preservation of the RLN occurs in 3 phases: phase 1, identifying the inferior thyroid artery (ITA); phase 2, identifying the RLN; and phase 3, dividing the ligament of Berry (LofB).[16]

We hypothesized that effortful moments of slowing down would be characterized by fixations of longer duration on critical structures and/or anchor locations. Anchor locations are areas that enable perceptual awareness not only of the object or location being fixated but relevant locations in the nearby vicinity. We expected highly experienced (HE) surgeons to slow down cognitively more than less experienced (LE) surgeons through the use of a long-duration QE on the RLN. For the purposes of our study, the QE was defined as the final fixation on the RLN before blunt and sharp dissections, movements with the greatest potential of harming the patient.

Methods

Three HE and 7 LE surgeons volunteered. Ethical approval was obtained through the University of Calgary Conjoint Health Ethics Research Board. The HE surgeons were subspecialists who self-reported that they had completed >200 thyroidectomies. The LE surgeons were 4th-year and 5th-year residents and/or general surgeons who self-reported <200 procedures. Although the exact length of the learning curve for thyroidectomy has not been exactly elucidated, it has been shown that surgeons with higher volume experience with thyroidectomy have decreased complications.[17] More recent studies of experienced thyroid surgeons' adopting new operative approaches (endoscopic or robotic) in thyroidectomy have shown the learning curve to be 50 cases.[18,19] If the learning curve in surgeons already considered "expert" in the basic procedure is this long, it is likely that the learning curve for a novice in thyroid surgery would be significantly longer. For this reason, we set the standard for HE surgeons very high at >200 and for LE surgeons lower than this.

Protocol

Each surgeon performed a thyroid lobectomy on a cadaver model, randomly assigned to the right or left side. The cadavers were prepared with the skin incision made, subplatysmal flaps raised, and strap muscles dissected off the thyroid. The same surgical instruments were made available to all the surgeons. After eye tracker fitting and calibration were complete, surgeons were read standard instructions to identify and dissect the RLN to its insertion at the level of the cricothyroid muscle with the same care that would be taken during an operation on a live patient. An assistant was provided for retraction at the direction of the surgeon.

Equipment

Gaze data were collected using the Mobile Eye tracker (Applied Sciences Laboratory, Bedford, MA) coupled to an external camera that videotaped the surgeon's hand movements. The Mobile Eye is a light (76 g), glasses-mounted, monocular corneal reflection system that measures point of gaze with an accuracy of 1.0° of visual angle, precision of .05°, and a frequency of 30 Hz (33.3 ms/frame). We coupled the duration of the surgeon's hand movements with their fixation and QE durations to specific surgical locations during the 3 phases (Fig. 1). Gaze and motor data were monitored continuously throughout the operation and synchronized later in the laboratory using Final Cut Pro (Apple Corporation, Cupertino, CA).

Data management and coding

Table 1 presents the number of thyroidectomies per surgeon, total operating time, total duration of the 3 phases, and the duration of each phase. Operative performance was quantified by independent, blinded review of the video data by an expert surgeon using the University of Toronto Global Rating Scale of Operative Performance. The phases