Simulation Training for Neuroendoscopy: A Canadian National Needs Assessment Survey

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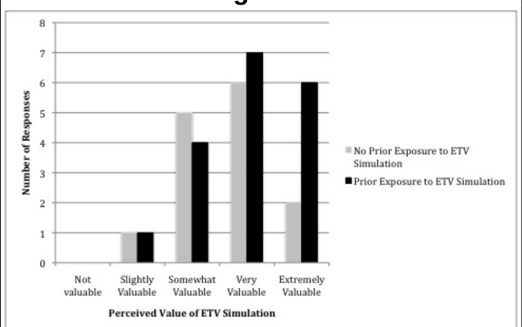
Introduction

Given recent technological advances, endoscopic third ventriculostomy (ETV) has become the standard-of-care for managing obstructive hydrocephalus.[1] However, ETV introduces novel challenges for surgical trainees, including loss of tactile feedback, adapting to a 2D visual environment, and manipulating instruments with very limited degrees of freedom in narrow, high-risk spaces.[2] The need to develop these skills provides a unique opportunity to introduce VR simulation training into the neurosurgical training paradigm. The purpose of this study was to conduct a national needs assessment, addressing specific goals of instruction, to guide the development of a VR simulator and curriculum for ETV.

Figure 1



Surgeon's opinions regarding the utility of virtual reality simulation training for ETV

Methods

Canadian neurosurgeons who perform ETV in their clinical practice were invited to participate. Using mixed-methods survey methodology, we developed a 10-item, structured, online questionnaire. Items pertained to the procedural steps for ETV, the frequency and significance of intraoperative errors committed while learning the technique, and simulation training modules of greatest potential educational benefit. Descriptive data analysis was completed for both quantitative and qualitative responses. Data were also analyzed for differences in mean response scores between surgeons with and without prior exposure to simulation for ETV.

Table 2: Procedural Steps to Simulate

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Rank	Procedural Step	Mean Score* (CI)
1	Selection of ventriculostomy site	4.84 (4.68-5.00)
2	Navigation within the ventricles	4.66 (4.44-4.87)
3	Performance of fenestration	4.56 (4.29-4.84)
4	Confirmation of adequacy of fenestration	4.28 (4.03-4.53)
5	Selection of cortical entry/trajectory	4.25 (4.01-4.49)
6	Instrument set-up (camera, tools, support arm, irrigation, etc.)	4.09 (3.81-4.37)
7	Removal of endoscope and inspection of fornix	3.94 (3.66-4.21)
8	Insertion of trocar/sheath into ventricle	3.75 (3.46-4.04)
9	Exposure (skin incision, burrhole, durotomy)	2.75 (2.37-3.13)
10	Closure	2.56 (2.17-2.95)

CI = 95% confidence interval
*Items scored on a 5-point Likert scale; 1 = not at all important, 2 = slightly important, 3 = somewhat important, 4 = very important, 5 = extremely important

Results

32 of 58 (55.2%) surgeons completed the survey. All believed a VR simulator for ETV would be a valuable addition to clinical training (Figure 1). Identification of ventriculostomy site, navigation within the ventricular system and performance of the ventriculostomy ranked among the most important steps to simulate. Technically inadequate ventriculostomy, inappropriate fenestration site selection and failure to abort the procedure appropriately were cited as the most frequent/significant errors. A standard module and technically unsafe ETV scenario were felt to be most beneficial for resident training.

Table 3: Frequency and Significance of Intraoperative Errors

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Rank	Intraoperative Error	Mean Frequency Score* (CI)	Mean Significance Score** (CI)	Composite Score***
1	Technically inadequate ventriculostomy (e.g. fenestration failure or inadequate size)	2.57 (2.31-2.82)	4.07 (3.79-4.34)	6.64
2	Failure to identify unsafe ETV	1.93 (1.56-2.30)	4.5 (4.19-4.81)	6.43
3	Failure to identify 3rd ventricular anatomy, improper ventriculostomy site selection	1.97 (1.63-2.30)	4.4 (4.17-4.63)	6.37
4	Improper camera/endoscopic instrument set-up (e.g. resulting in rotated/unfocussed image)	2.67 (2.28-3.05)	3.63 (3.22-4.04)	6.3
5	Neural injury (e.g. fornix, thalamus, etc.)	2.53 (2.23-2.84)	3.73 (3.38-4.09)	6.26
6	Injury to basilar/brainstem	1.3 (0.99-1.61)	4.9 (4.75-5.00)	6.2
7	Failure to fenestrate Lillequist membrane	2.53 (2.28-2.79)	3.6 (3.25-3.95)	6.13
8	Improper site of cortical entry	2.23 (1.88-2.58)	3.8 (3.52-4.08)	6.03
9	Improper trocar/sheath insertion trajectory	2.17 (1.86-2.48)	3.77 (3.45-4.09)	5.94
10	Excessive force handling endoscope/tools	2.4 (2.07-2.73)	3.5 (3.10-3.90)	5.9
11	Poor depth perception resulting in inappropriate endoscope/tool manipulation	2.0 (1.67-2.33)	3.63 (3.22-4.04)	5.63
12	Improper irrigation setup (blurry image)	2.33 (1.96-2.70)	3.37 (3.02-3.71)	5.7
13	Failure to manage bleeding from choroid/ependyma	2.4 (2.0-2.8)	3.07 (2.63-3.50)	5.47
14	Poor skin closure leading to CSF leak	1.43 (1.13-1.74)	2.93 (2.57-3.30)	4.36

Additional Errors: release of excess CSF upon trocar insertion, advancement of the trocar too deeply upon insertion

CI = 95% confidence interval; CSF = cerebrospinal fluid; ETV = endoscopic third ventriculostomy
* Items scored on a 5-point Likert scale; 1 = not often at all, 2 = occasionally, 3 = sometimes, 4 = frequently, 5 = always
** items scored on a 5-point Likert scale; 1 = not significant at all, 2 = slightly significant, 3 = somewhat significant, 4 = very significant, 5 = extremely significant
*** Composite score = sum of mean frequency and significance scores

Table 4: Simulation Modules of Benefit

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Rank	Simulation Module/Characteristic	Mean Score* (CI)
1	Standard ETV (normal anatomy, simple perforation)	4.31 (4.09-4.54)
2	Technically unsafe ETV	4.10 (3.79-4.41)
3	Improper trajectory (crossover into contralateral ventricle)	4.07 (3.87-4.27)
4	Excess endoscopic bleeding	4.03 (3.71-4.36)
5	Inappropriate set-up (unfocussed/rotated image, irrigation failure, no support arm)	4.00 (3.77-4.23)
6	Thickened 3rd ventricle floor	3.93 (3.61-4.25)
7	Force feedback exercise (feedback when excess force has caused neural injury)	3.79 (3.50-4.09)
8	Depth exercise (identify anatomical landmarks to determine endoscope/tool depth)	3.79 (3.45-4.14)
9	Lillequist membrane fenestration	3.76 (3.46-4.06)
10	Identification of traction injury to fornix	3.31 (2.96-3.66)

CI = 95% confidence interval; ETV = endoscopic third ventriculostomy
*Items scored on a 5-point Likert scale; 1 = not at all useful, 2 = slightly useful, 3 = somewhat useful, 4 = very useful, 5 = extremely useful

Conclusions

As a first step in developing a simulation-training program for neuroendoscopy, we have conducted a national survey of attending surgeons regarding the training needs for endoscopic third ventriculostomy. The results provide valuable insight to inform key design elements necessary to construct an educationally relevant device and educational program.

References

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