Complication rates of external ventricular drain insertion by surgeons of different experience

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ABSTRACT

INTRODUCTION Insertion of external ventricular drain (EVD) is a widely accepted, routinely performed procedure for treatment of hydrocephalus and raised intracranial pressure. The purpose of this study was to investigate whether a surgeon's experience affects the associated complication rate.

METHODS This retrospective study included all adult patients undergoing EVD insertion at a single centre between July 2013 and June 2015. Medical records were retrieved to obtain details on patient demographics, surgical indication, risk factors for infection and use of anticoagulants or antiplatelets. Surgeon experience, operative time, intraoperative antibiotic prophylaxis, need for revision surgery and EVD associated infection were examined. Information on catheter tip position and radiological evidence of intracranial haemorrhage was obtained from postoperative imaging.

RESULTS A total of 89 patients were included in the study. The overall infection, haemorrhage and revision rates were 4.8%, 7.8% and 13.0% respectively, with no significant difference among surgeons of different experience. The mean operating time for patients who developed an infection was 22 minutes while for those without an infection, it was 33 minutes ($p=0.474$).

Anticoagulation/antiplatelet use did not appear to increase the rate of haemorrhage. The infection rate did not correlate with known risk factors (eg diabetes and steroids), operation start time (daytime vs out of hours) or duration of surgery although intraoperative (single dose) antibiotic prophylaxis seemed to reduce the infection rate. There was also a correlation between longer duration of catheterisation and increased risk of infection.

CONCLUSIONS This is the first study demonstrating there is no significant difference in complication rates between surgeons of different experience. EVD insertion is a core neurosurgical skill and junior trainees should be trained to perform it.

KEYWORDS

Ventriculostomy – Medical education – Nosocomial infection

Accepted 16 October 2017

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Insertion of an external ventricular drain (EVD), also known as ventriculostomy catheter, is the routine surgical treatment for hydrocephalus and raised intracranial pressure. This relieves intracranial pressure and provides a way to measure it accurately.

Common complications following EVD insertion include haemorrhage, misplacement, dislodgement, blockage and infection, which could be further complicated by ventriculitis, meningitis, brain abscess or subdural empyema.¹ These are associated with increased length of hospital stay, morbidity and mortality.²

Insertion of EVD is a core neurosurgical procedure that is commonly taught to and performed by junior trainees. Indeed, it is an essential part of the UK³ and US⁴ neurosurgical training curricula. In the UK, the pathway of neurosurgical training involves completion of two foundation years followed by an eight-year specialty registrar training programme (ST1–ST8) after rigorous national selection. On completion of training, most trainees become consultants. Although the majority of EVD insertions are generally

performed by more junior trainees, in our experience, more senior trainees or even consultants would be asked to operate in certain cases because of the on-call roster and urgent nature of these cases.

Consequently, it is important to ascertain the safety of such procedures in the hands of neurosurgeons of different experience. The aim of this study was to retrospectively evaluate the complication rates for different surgeon grades performing EVD insertion in a single tertiary neurosurgical centre in the UK. To our knowledge, this is the first study that has examined the correlation between surgeon experience and complication rates for this procedure.

Methods

The first EVD insertion procedures in all adult patients (International Classification of Diseases code 009600Z) in a single neurosurgical unit over a period of two years (May 2013 – May 2015) were included in this retrospective study. Any subsequent reoperations were excluded to avoid

confounders. Patients whose medical records could not be retrieved were also excluded. The study was registered as an audit in the neurosurgical department and was approved by the hospital audit department.

Data collection included three aspects:

- > Patient factors – demographics, risk factors for infection (steroids, diabetes mellitus or alcoholism), use of anti-coagulants or antiplatelets, indication for surgery and EVD or ventriculoperitoneal shunt insertion prior to period of study
- > Surgeon factors – grade of primary surgeon
- > Operation factors – duration of surgery, start time of surgery, use of antibiotic prophylaxis, use of neuronavigation, any revision surgery and any EVD associated infection (defined as EVD infection requiring subsequent antibiotic treatment), position of catheter tip and presence of ventriculostomy associated haemorrhage in the postoperative computed tomography (CT) closest to operation

For analysis of the EVD associated infection rate, patients were excluded if they had already been on a course of antibiotics preoperatively during the admission (eg those who suffered from pneumonia or urinary tract infection prior to surgery). Patients who had no postoperative imaging were excluded from analysis of the haemorrhage rate.

The three main types of EVD used in our centre are Bactiseal® (product code 82-1745; impregnated with clindamycin 0.15% and rifampicin 0.054%; Codman, Raynham, MA, US), EDS® 3 (Codman), and external drainage and monitoring system (Medtronic, Dublin, Ireland) catheters. No patients were excluded from the study owing to having a particular type of drain. Frontal EVDs were inserted via burr holes in all cases, with tunnelling of the EVD for at least 5cm.

Statistical analysis

Data were analysed with SPSS® version 20.0 (IBM, New York, US). Chi-squared and Fisher’s exact tests were employed to compare differences in distribution. Analysis of variance was used to investigate differences in operating time and duration of catheterisation. A *p*-value of <0.05 was considered statistically significant.

Results

Using our clinical codes, 154 patients were identified as having undergone EVD insertion during the study period. Medical notes could not be retrieved for 65 patients, mainly because they were in possession of other departments for ongoing care or being used by the medical coding team. This left 89 procedures for analysis. Forty (45%) of the patients were male. The mean age was 58 years (standard deviation: 17 years). There was no temporal bias with regard to the sampling of notes. The indications for surgery are shown in Figure 1.

Surgeon experience

The grades of surgeons (primary surgeon on operating notes) were categorised into three groups as per the UK training system: grade 1 (most junior) being ST3 or below, grade 2 being ST4–ST6 and grade 3 being ST7 or above (including consultants). Grade 1 surgeons performed only 20 of the 89 EVD insertions while grade 2 and grade 3 surgeons performed 35 and 34 respectively.

A summary of the rates of the main complications is given in Table 1. There was no statistically significant difference between the surgeon grades in terms of infection, haemorrhage or revision operation. The mean operating time was also comparable across all grades.

Figure 1 Indications for external ventricular drain

Table 1 Complication rates and mean operative time by surgeon grade

	Grade 1 (most junior)	Grade 2	Grade 3	Overall	p-value
Infection	1/20 (5.0%)	0/33 (0%)	3/30 (10.0%)	4/83 (4.8%)	0.180
Haemorrhage	0/14 (0%)	2/31 (6.5%)	4/32 (12.5%)	6/77 (7.8%)	0.325
Revision	3/20 (15.0%)	4/35 (11.4%)	5/34 (14.7%)	12/89 (13.5%)	0.900
Mean operative time in mins	36 (SE: 5.4)	34 (SE: 3.0)	28 (SE: 5.5)	33 (SE: 2.6)	0.515

SE = standard error

Proximal catheter tip placement was classified into five groups according to anatomical site: frontal horn of ipsilateral ventricle, frontal horn of contralateral ventricle, third ventricle, brain parenchyma and 'other'. Twenty-three patients had no CT following surgery; these cases were classified as 'unknown' and excluded from analysis, leaving 66 cases (15 EVDs inserted by grade 1, 26 by grade 2 and 27 by grade 3 surgeons). The distribution of the position of the proximal catheter tip (as identified in postoperative CT) is illustrated in Figure 2. The ipsilateral frontal horn was the most common site for EVD placement (grade 1: 10/13 [77%], grade 2: 18/26 [69%], grade 3: 20/27 [74%]). This was independent of surgeon experience ($p=0.541$).

Considering the baseline of the different surgeon grades, there was no significant difference in indications, immunodeficiency rate or anticoagulation/antiplatelet rate ($p=0.230$, $p=0.065$ and $p=0.725$ respectively).

Infection

Six patients had prior antibiotic treatment and were excluded from infection related analysis, leaving eighty-three cases. Seventeen patients were immunocompromised

(eg on steroids or with diabetes mellitus). This subgroup had an infection rate of 0%. Among the remaining 66 patients, 4 (6.1%) developed an infection ($p=0.577$). All four identified cases of infection had coagulase negative *Staphylococcus* present in their cerebrospinal fluid (CSF) culture with one case also positive for *Streptococcus oralis*.

The mean operating time for the uninfected group was 33 minutes (standard error [SE]: 2.8 minutes) and that for the infected group was 22 minutes (SE: 2.5 minutes). This difference was not statistically significant ($p=0.474$).

Of the nine patients without intraoperative (single dose) antibiotic prophylaxis, three (33%) developed an infection. In contrast, among the 74 patients who had antibiotics, the infection rate was 1.4% ($n=1$). This difference was statistically significant ($p=0.003$). Only the first EVDs inserted during the period of the study were included in analysis. Four patients had a ventriculoperitoneal shunt removed at the same time as EVD insertion and the EVD insertions of four patients were revision operations. These eight cases were not associated with increased infection risk ($p=0.339$).

Start time of operation was divided into daytime working hours (8am – 6pm) and out of hours. The operations of 33

Figure 2 Distribution of position of proximal catheter tip for the different surgeon grades

(40%) of the 83 cases included in infection related analysis started during daytime working hours. This did not affect the infection rate ($p=0.523$).

The mean duration of catheterisation in the non-infected group was 8.7 days (range: 1–34 days) and that in the infected group was 21.8 days (range: 12–27 days), showing a statistically significant difference ($p=0.028$). The overall mean was 9.1 days. There was no difference in duration of catheterisation between different surgeon grades ($p=0.092$).

The catheter type was identified in 72 of the 83 patients who were not taking antibiotics preoperatively (Table 2). There was no significant difference in infection rate between the three EVD types ($p=0.092$).

Haemorrhage

Twelve patients had no postoperative imaging and so their haemorrhage rate could not be determined. This left 77 cases for analysis. Eleven patients were on anticoagulation or antiplatelet therapy (4 aspirin, 3 clopidogrel, 2 warfarin, 1 dabigatran, 1 unfractionated heparin). Among these cases, the haemorrhage rate was 18.2% ($n=2$) whereas in the remaining 66 patients, it was 6.1% ($n=4$). This difference was not statistically significant ($p=0.202$). None of the haemorrhages required surgical intervention.

Position of EVD

The majority of the burr holes ($n=72$, 81%) were positioned on the right side at Kocher's point, as per convention. Fifteen EVDs were inserted in the left frontal lobe. Bilateral EVD insertions ($n=2$) were categorised as a single procedure. Image guidance ($n=4$) did not appear to lead to a difference in distribution of catheter position ($p=0.160$).

Discussion

The main limitation of our study is the small sample size but it is the first to demonstrate the safety of EVD insertion in the hands of junior surgeons. In this single centre study, complication rates did not differ significantly between surgeons of different grades. These results show that junior surgeons should be given the opportunity to perform these cases, with appropriate supervision. Prolonged operating time increases risk of general anaesthesia and cost but our

findings reveal that surgeons of different grades had similar operating times.

The main question of this study was whether junior surgeons should be allowed to perform these procedures *under appropriate supervision* (whether or not the trainer was scrubbed during the procedure). The level of the supervision should depend on the competency and confidence of the individual surgical trainee involved. The majority of the procedures carried out by grades 2 and 3 were performed independently while the majority of cases undertaken by grade 1 surgeons were supervised by a senior surgeon in the operating theatre at the time.

Middle grade trainees appeared to have the lowest infection and revision rates whereas junior trainees had the lowest haemorrhage rate. Senior trainees and consultants (grade 3) were grouped together in our categorisation because although consultants may be considerably more experienced than senior trainees, EVD insertion is a routine emergency procedure that all senior trainees should be able to perform confidently and with familiarity similar to that of a consultant. Furthermore, there was no significant difference in the baseline demographics of the patients operated on between different surgeon grades, ensuring a fair comparison.

Recent studies have been performed in the neurosurgical field to show how operative experience affects the learning curve but most of them concern elective operations such as acoustic neuroma surgery,⁵ endoscopic pituitary surgery⁶ and lumbar microendoscopic discectomy.⁷ Only a few studies have looked into procedures of a more urgent nature such as drainage of subdural haematoma.⁸ In our experience, some of these emergency procedures including EVD insertion are learnt using a 'see one, do one, teach one' approach and junior surgeons are often assumed to be competent to perform these to an adequate standard. However, in the era of evidence-based medicine, studies such as the one reported here would be necessary to support that conclusion.

Insertion of EVDs is usually time critical for the management of acutely deteriorating patients and the on-duty junior surgeon is often the first available person who may perform the procedure. It is therefore important to ensure he or she is competent to manage the patient adequately with outcomes that are comparable with those of more senior surgeons. We believe this is the first study that provides evidence for this.

The main focus of this study was to examine the effect of surgeon experience but other factors that may potentially influence EVD complication rates were also investigated. Immunodeficiency and anticoagulation/antiplatelet therapy did not alter the infection rate or haemorrhage rate respectively. Previous EVD or shunt insertion and operation start time did not increase the infection rate either but intraoperative (single dose) intravenous antibiotics administration was associated with a significant reduction in infection rate. Infected cases did not have a significantly longer operating time than non-infected cases. It is appreciated that one cannot exclude the possibility that other medical conditions and medications may also play a role in the development of

Table 2 Correlation between type of external ventricular drain (EVD)* and infection

	Infection		Total
	Negative	Positive	
EVD type 1	17	3	20
EVD type 2	43	1	44
EVD type 3	8	0	8
Total	68	4	72

*1 = Bactiseal® (Codman); 2 = EDS® 3 (Codman); 3 = external drainage and monitoring system (Medtronic)

infection but at least some of the more common risk factors have been included.

Published EVD infection rates vary between 3.9% and 19%.^{9–18} Our overall infection rate of 4.8% lies within this range. Camacho *et al* identified the length of time the catheter was in place (overall mean: 6.5 days per catheter) as the only independent risk factor; antibiotic prophylaxis was not associated with infection rate.¹⁷ This is supported by our findings although having only four infected cases could have skewed our results. Other studies suggest that duration of operation is not a risk factor,^{11,12,15} also consistent with our study. Additional risk factors for infection quoted in the literature include previous EVD insertion¹⁵ as well as presence of intraventricular blood and previous trauma.¹⁶ Previous EVD insertion was not a significant risk factor in our study. The exact risk factors, however, remain contentious.¹

Differences in infection rate may be accounted for by the various criteria authors have adopted for EVD associated infection. In our study, a pragmatic approach was taken and infections were defined as those that clinically require antibiotic treatment. In all the cases identified in our study, there were positive CSF cultures, making them more likely to be genuine infection.

The theoretical benefit of antibiotic impregnated catheters reducing EVD and shunt associated infection rates was not reproduced in our study. The currently available evidence is inconclusive.^{18–20} There is also the theoretical albeit not proven risk of such catheters harbouring antibiotic resistant organisms.^{21,22} Larger studies are required to ascertain their benefits.

Studies show that haemorrhage rates vary between 33% and 44%.^{14,23} These rates are surprisingly much higher than the overall haemorrhage rate of 7.8% in our study. A possible reason is that the postoperative imaging in these other studies was performed within a strict time limit of 24 or 48 hours. Some of our imaging, however, was performed later and so any small haemorrhages could have been reabsorbed. There was also a heterogeneous distribution of anti-coagulant/antiplatelet use in our patients and the safety of individual blood thinners warrants further investigation.

Image guidance did not appear to alter catheter position. This was to be expected as EVD insertion is a long established procedure and most patients had ventriculomegaly preoperatively. Furthermore, the sample size was too small to make a justifiable conclusion relating to image guidance.

Conclusions

This study has shown that the complication rate among surgeons of different experience does not differ significantly for EVD insertion. Junior trainees should therefore be encouraged to perform this core neurosurgical procedure with appropriate supervision and guidance.

Acknowledgement

The authors would like to thank Theatre Sister Ms Della Ball and Dr Rebecca Wosley from the clinical audit department for their contribution to data collection.

The material in this paper was presented at the European Association of Neurosurgical Societies Congress held in Athens, Greece, September 2016.

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