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External ventricular drain placement in the intensive care unit versus operating room: Evaluation of complications and accuracy

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ABSTRACT

Objective: External ventricular drain (EVD) placement is a common neurosurgical procedure performed in both the intensive care unit (ICU) and operating room (OR). The optimal setting for EVD placement in regard to safety and accuracy of placement is poorly defined.
Methods: A retrospective chart review was performed on 150 consecutive patients who underwent EVD placement at a tertiary care center from January of 2013 to February of 2014. Clinical and radiographic data were obtained and used to compare safety and accuracy of placement between EVDs placed in the ICU versus OR.
Results: One hundred and thirty eight patients were evaluated. Complications (hemorrhage, infection, non-functional drain) occurred in 21.5% of ICU placements and 6.7% of OR placements ($p = 0.028$). Grade 1, 2, and 3 placements occurred in 67.7%, 25.8%, and 6.5% of ICU placements, respectively, versus 55.6%, 42.2%, and 2.2% of OR placements ($p = 0.258$). No patient who received pre-placement antibiotics suffered a ventriculostomy associated infection (VAI).
Conclusion: Patients who underwent ventriculostomy placement in the ICU differed in important ways (i.e. indication for placement and the administration of pre-procedure prophylactic antibiotics) from patients treated in the OR. However, the available data suggests that complications of hemorrhage, infection, and non-functional drains may be mitigated by ventriculostomy placement in the OR.

1. Introduction

External ventricular drain (EVD), aka ventriculostomy, placement is a common neurosurgical procedure. External ventricular drains are placed for the treatment of hydrocephalus (HCP) and provide a means of monitoring intracranial pressure. These devices are utilized in the management of a wide array of neurosurgical pathology including subarachnoid hemorrhage (SAH), trauma, intraventricular hemorrhage (IVH), cerebrospinal fluid (CSF) leaks, and hydrocephalus from a variety of other neurosurgical disorders. While these procedures are generally regarded as safe, there remains a significant risk of complications.

Complications of EVD placement involve hemorrhage, infection, and improper placement resulting in a non-functional device that requires replacement, thus subjecting the patient to an additional procedure. There exists a significant body of literature focusing on the reduction of these complications, with the majority addressing issues involving either the procedure itself or instruments utilized for the placement or the post-placement care of the device. We seek instead to evaluate the EVD placement environment, specifically the intensive care unit (ICU) versus the operating room (OR), with respect to complications and accuracy of placement.

2. Methods

Following approval from the institutional review board, we conducted a retrospective chart review of 150 consecutive patients undergoing external ventricular drain placement at a tertiary referral center from January 2013 to February 2014. Twelve of the 150 patients were excluded: 8 due to lack of imaging following external ventricular drain placement and 4 due to use of image guidance during ventriculostomy placement (3 Stealth guided, 1 pen endoscope). Therefore a total of 138 patients were included in the study. Only the first ventriculostomy was evaluated in patients that underwent multiple ventriculostomy placements during their hospitalization. No patient was included twice.

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Clinical and radiographic data were collected via chart review. Data including age, gender, indication for EVD placement, setting of EVD placement, coagulation parameters, presence of antibiotic therapy at the time of placement, presence of anti-thrombotic use prior to EVD placement, catheter tract hemorrhage, EVD associated infection, image guidance for EVD placement, and need for revision was extracted. If a subarachnoid hemorrhage patient also demonstrated intraventricular hemorrhage, they were grouped as a subarachnoid hemorrhage. External ventricular drain tract hemorrhages were graded according to the scale proposed by Jackson et al.: grade 0, no tract hemorrhage, grade 1, trace tract hemorrhage, grade 2, tract hemorrhage associated with intracerebral hematoma (ICH), grade 3, massive tract hemorrhage with mass effect [1]. Hemorrhage grading was based on the first cranial imaging (CT or MRI) obtained following EVD placement. External ventricular drain infection was defined as a positive CSF culture obtained from the EVD. This did not include positive CSF cultures obtained from a pre-existing indwelling ventricular shunt (i.e. shunt infection). Accuracy of placement was graded according to the grading scale proposed by Kakarla et al.: grade 1, ipsilateral frontal horn, including tip of third ventricle, grade 2, contralateral frontal horn or lateral ventricle, corpus callosum, interhemispheric fissure, grade 3, brainstem, cerebellum, internal capsule, basal ganglia, thalamus, occipital cortex, and basal cisterns [2].

2.1. External ventricular drain placement

External ventricular drain placement follows a set of general principles with modifications for certain clinical conditions (i.e. placement in OR with an associated surgical procedure). Placement of the catheter is performed by a neurosurgical resident or attending. Location of EVD placement is determined by the clinical situation; however, a right frontal location (Kocher's point) is the preferred location [3]. Standard procedure includes clipping hair followed by a Betadine scrub and paint. Once the area has dried, the patient is draped and a small amount of lidocaine with epinephrine is injected into the scalp for anesthesia and hemostasis. A scalp incision is then made and the periosteum separated from the skull. A burr hole is performed with either a twist drill or high-speed drill with care not to injure the dura or underlying brain. Once bone dust and debris has been removed from the burr hole, the dura is sharply opened. A ventricular catheter impregnated with minocycline and rifampin (VentriClear II EVD Catheter, Medtronic Inc., Minneapolis, MN) is then placed utilizing external landmarks while maintaining an orthogonal trajectory with respect to the skull. After CSF is obtained, the catheter is then tunneled through the scalp and secured with a purse string suture. The scalp incision is then closed with a running nylon and a Primapore (Smith & Nephew Inc., St. Petersburg, FL) dressing is applied. The ventricular catheter is then connected to an external drainage system equipped for quantifying volume of drainage and measuring intracranial pressure (ICP). Cerebrospinal fluid is routinely obtained on Monday, Wednesday, and Friday and sent for glucose, protein, cell count, gram stain, and culture. Notably, pre- and post-procedural prophylactic antibiotics are not given routinely for EVD placement in the ICU. However, patients with EVDs placed in the OR receive pre-procedure prophylactic antibiotics but do not receive post-procedure prophylactic antibiotics. Antibiotic selection is at the discretion of the surgeon. A cephalosporin is generally first line and clindamycin is substituted if cephalosporin or penicillin allergies are present.

2.2. Statistical methods

Descriptive and statistical analyses were performed using commercially available software (IBM SPSS Statistics for Windows, Version 21.0). Categorical variables were tested for statistical significance using Fisher's exact test and Chi-squared test. Mann Whitney *U* test and Kruskal–Wallis one-way analysis of variances were applied for ordinal variables, Bonferroni correction was applied for multiple analyses and posthoc comparisons. Univariate and multivariate analysis have been performed. A binary logistic regression model with backward elimination was performed with all complications versus no complications as dependent variables and history of trauma (yes versus no), INR (greater than and equal versus less than 1.4), antibiotic administration (yes versus no), placement setting (ICU versus OR) as independent variables. Collinearity statistics and diagnostics (tolerance, variance inflation factor, condition index, and variance proportions) were checked according to recommended guidelines. A p value >0.05 in the Nagelkerke R^2 indicated a valid predictive power of the model.

3. Results

3.1. Intensive care unit versus operating room

One hundred and thirty eight consecutive patients undergoing external ventricular drain placement were included. Ninety-three (67.4%) patients had EVDs placed in the ICU and 45 (32.6%) patients had EVDs placed in the operating room. Patients ranged from 15 to 88 years of age. Indications for ICU EVD placement: 41 (44.1%) head traumas, 19 (20.4%) subarachnoid hemorrhages, 14 (15.1%) intraventricular hemorrhages, 2 (2.2%) shunt malfunctions, 2 (2.2%) shunt infections, 3 (3.2%) hydrocephalus unspecified, 8 (8.6%) tumors, and 4 (4.3%) intracerebral hemorrhages. Indications for OR EVD placement: 3 (6.7%) head trauma, 8 (17.8%) subarachnoid hemorrhage, 2 (4.4%) intraventricular hemorrhage, 3 (6.7%) shunt malfunction, 3 (6.7%) shunt infection, 2 (4.4%) chiari malformation, 5 (11.1%) unspecified hydrocephalus, 11 (24.4%) tumor, 6 (13.3%) cerebrospinal fluid leak, 2 (4.4%) encephalocele, and 1 (2.2%) intracerebral hematoma. Patients received pre-EVD placement antibiotics in 10 (10.8%) of ICU placements and 45 (100%) of OR placements (Table 1).

Complications (hemorrhage, infection, or a non-functional EVD) occurred in 20 (21.5%) of ICU placed EVDs and 3 (6.7%) of OR placed EVDs ($p = 0.028$). Fourteen (15.1%) hemorrhages occurred in ICU placements and 2 (4.4%) in OR placements (p-value = 0.068). Infection occurred in 4 (4.3%) of ICU placements and no OR placements (p-value = 0.303). Non-functional EVDs occurred in 5 (5.4%) and 1 (2.2%) of ICU and OR EVD placements ($p = 0.664$), respectively. Accuracy of placement in ICU: 63 (67.7%) grade 1, 24 (25.8%) grade 2, and 6 (6.5%) grade 3. Accuracy of placement in OR: 25 (55.6%) grade 1, 19 (42.2%) grade 2, and 1 (2.2%) grade 3. Accuracy of placement in ICU versus OR was not statistically significant ($p = 0.258$). Revision of the EVD was done in 11 (11.8%) ICU and 1 (2.2%) OR-placed EVDs ($p = 0.103$) (Table 1).

3.2. Operating room with additional procedure versus without additional procedure

Among the 45 patients with EVDs placed in the OR, 35 (77.8%) underwent an associated surgical procedure and 10 (22.2%) underwent only EVD placement. Complications (hemorrhage, infection, and non-functional EVD) occurred in 3 (8.6%) of OR placements with additional procedure and 0 of OR placements without additional procedure ($p = 1.00$). Accuracy of placement and revision rates in OR placement with additional procedure versus without additional procedure were not statistically significant ($p = 0.396$ and $p = 0.222$, respectively) (Table 2).