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Shunts: Is Surgical Education Safe?

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■ BACKGROUND: **More data regarding complications in neurosurgery residents' cases are needed to assess patients' safety during hands-on surgical education.**

■ METHODS: **A retrospective 2-center study was performed comparing consecutive patients undergoing shunt implantation by a supervised neurosurgery resident (teaching cases) versus a board-certified faculty neurosurgeon (nonteaching cases). The primary end point was surgical revision after shunting. Univariate and multivariate Cox proportional hazard models (Breslow method for ties) with time censored at 2 years were used to examine time-to-event data. Operation time, length of hospitalization, intracranial hemorrhage, and misplacement of the shunt catheter were other outcome measures to be compared between the groups.**

■ RESULTS: **A total of 320 shunts (180 [56.3%] teaching and 140 [43.7%] nonteaching cases) with a mean follow-up of 563 ± 771 days (standard deviation) were analyzed. Revision rates for the entire cohort were 9.3% at 90 days, 13.3% at 6 months, 18.4% at 1 year, and 26.5% at 2 years. In univariate analysis, teaching cases were 96% as likely as nonteaching cases to be surgically revised (hazard ratio, 0.96; 95% confidence interval, 0.54–1.70; $P = 0.877$). In multivariate analysis adjusted for indication and shunt type, teaching cases were 94% as likely as nonteaching cases to undergo surgical revision (hazard ratio, 0.94; 95% confidence interval, 0.53–1.69; $P = 0.847$). There were no group differences in operation time, length of hospitalization, intracranial hemorrhage, and rates of shunt misplacement.**

■ CONCLUSIONS: **The results of the current study in addition to the literature on neurosurgery resident training support the safety of supervised early surgical education for shunt surgery.**

INTRODUCTION

In previous reports, surgical education within the framework of a structured residency training program has been shown to be safe in cervical and lumbar spine surgery,[1-4] as well as in 1 standard cranial procedure, namely cranioplasty.[5] Nonetheless, more data are needed to ensure that patients can safely undergo surgery by supervised residents. This debate is even more important now since the introduction of European work-hour restrictions.[6,7] The implantation of shunt systems for cerebrospinal fluid (CSF) diversion is another common neurosurgical procedure in which residents are frequently allowed to participate early in their training. It entails a burr-hole trephination for ventriculostomy, which is an often-performed procedure, especially

Key words
- Complication
- Hydrocephalus
- Outcome
- Resident training
- Risk
- Safety
- Shunt
- Surgical education

Abbreviations and Acronyms

BCFN: Board-certified faculty neurosurgeons
CI: Confidence interval
CSF: Cerebrospinal fluid
HR: Hazard ratio
HUG: University Hospital Geneva
ICH: Intracranial hemorrhage
IV: Intravenously
KSSG: Cantonal Hospital St. Gallen
NPH: Normal pressure hydrocephalus
PGY: Postgraduate year
SAH: Subarachnoid hemorrhage
SD: Standard deviation

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by junior residents.[8] However, shunts per se are prone to many complications, including infection and obstruction with subsequent revision surgery.[9,10] Thus, we tested the hypothesis that revision and complication rates of supervised residents and experienced board-certified faculty neurosurgeons (BCFN) are similar.

METHODS

Study Design and Patient Identification

Patient electronic charts of all consecutive de novo shunt operations from 2 Swiss teaching hospitals between January 2009 and September 2015 (Cantonal Hospital St. Gallen [KSSG]), as well as January 2009 and May 2014 (University Hospital Geneva [HUG]) were retrospectively reviewed at the end of 2016. Patients with missing relevant clinical and radiologic data were excluded, as were those patients in whom a shunt complemented another cranial procedure (e.g., cranioplasty), which has been reported to result in more complications when performed in combination with a shunt operation.[11] Likewise, a previous shunt procedure in the same patient was an exclusion criterion, because this is a known risk factor for subsequent shunt revision surgery.[12] We included patients from all age-groups.

Study Groups and Education Program

Dichotomization was performed for teaching cases (patients operated on by a neurosurgery resident in postgraduate year [PGY] 1 to PGY6) and nonteaching cases (patients operated on by a BCFN).[1-5] At KSSG, residents fulfill the requirements to perform their first shunt operation after 18 months of training. At HUG, residents are allowed to act as the primary surgeon for this procedure from their first year onward.

Group assignment usually depended on which surgeon was involved in the index case to maintain continued patient care.[5] The surgeon's training level was fully disclosed to patients and/or their next-of-kin. Teaching cases were (almost) independently and completely performed by the trainee, although the BCFN was usually scrubbed in for supervision, guiding movements and sometimes performing the cranial or abdominal approach simultaneously to keep operation time short. When the BCFN overtook additional key parts of the procedure (in case of any arising difficulties, e.g. with the ventriculostomy [maximum 3 attempts], trocar passing, the abdominal approach), then the case became a crossover and was declared a nonteaching case as in previous studies.[1-5]

Sample Size Calculation

We found no comparisons between residents and BCFN with respect to the rates of surgical revision after shunting in the literature. Generally, revision rates range between 22% and 40%.[9,12,13] In clinical research, effect sizes (odds ratios) $\geq$2.5 are considered clinically meaningful. Based on these numbers, we assumed a complication rate of 30% in teaching cases and 15% in nonteaching cases, which translates into the smallest clinically meaningful effect size (odds ratio, 2.5). Sample size calculation showed that 121 patients per group were needed to detect a difference with a power of 80% and α set at 0.05.

Data Collection

Patients' baseline characteristics including age, sex, body mass index, and their underlying diagnosis requiring CSF diversion were recorded, as well as the type of shunt implanted and whether or not a previous CSF infection had been present. Preoperative serum C-reactive protein level was noted. As the documentation of minor clinical events during the hospitalization was of varying quality, in this study, we recorded only complications significant enough to result in revision surgery (e.g., catheter misplacement, disconnection, blockage, infection, hemorrhage). Furthermore, details of infectious pathogens, as well as operation time and length of hospitalization, were extracted from the electronic charts. All postoperative computed tomography scans were

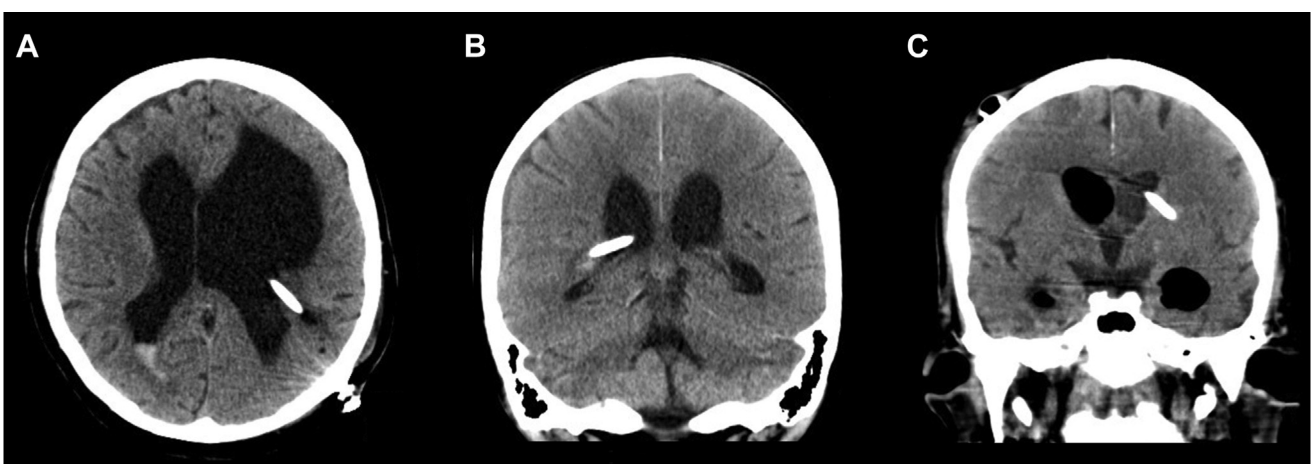

Figure 1. Radiologic findings after shunt insertion: intraventricular hemorrhage (**A**), intraparenchymal hematoma along the catheter (**B**), and shunt misplacement (**C**) (figure shows the catheter tip located in the lateral parenchyma of the contralateral ventricle).