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Key perspectives on the learning curve of pedicle screw placement, stereotactic radiosurgery for brain metastases, growth of incidentally found meningiomas, and the Barrow Ruptured Aneurysm Trial

Angela Bohnen, Jonathan H. Sherman[1], Panayiotis Pelargos[2], Isaac Yang[2], Visish M. Srinivasan[3], Edward A. M. Duckworth[3], Winward Choy, Zachary A. Smith

Department of Neurosurgery, Northwestern University Feinberg School of Medicine, Chicago, IL, [1]Department of Neurosurgery, George Washington University School of Medicine and Health Sciences, Washington, D.C., [2]Department of Neurosurgery, University of California Los Angeles David Geffen School of Medicine, Los Angeles, CA, [3]Department of Neurosurgery, Baylor College of Medicine, Houston, TX, USA

E-mail: Angela Bohnen - angela-bohnen@northwestern.edu; Jonathan H. Sherman - jsherman@mfa.gwu.edu; Panayiotis Pelargos - ppelargo@uci.edu; Isaac Yang - iyang@mednet.ucla.edu; Visish M. Srinivasan - visish.srinivasan@bcm.edu; Edward A. M. Duckworth - duckwort@bcm.edu; Winward Choy - winward.choy@northwestern.edu; *Zachary A. Smith - zachary.smith@northwestern.edu
*Corresponding author

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THE LEARNING CURVE OF PEDICLE SCREW PLACEMENT: HOW MANY SCREWS ARE ENOUGH?[2]

Study Question: What is the number of pedicle screws (PSs) necessary to gain competency in task performance?

PSs placed by a spinal surgical fellow (SSF) without prior experience under Attending Spinal Consultant (ASC) supervision from two tertiary spinal centers in Australia were investigated. All patients had postoperative radiographic studies, X-ray (XR) and/or computed tomography (CT), which were graded by two blinded and independent observers. Screws were graded as "acceptable" (contained within the pedicle or <30% screw diameter breach of the pedicle or vertebral body) and "misplaced" (>30% screw diameter outside the pedicle/vertebral body). For XR, this was denoted as XR1 and XR2, respectively. The same was used for CT; however, CT1 was subdivided into CT1A, "correct" (entirely contained in the pedicle), and CT1B, "borderline" (<30% screw violation). Screws placed by the SSF early in the training period were compared with those placed at the end of training to assess the learning curve. "Expert proficiency" was defined as the average misplacement performed by the ASC and defined the end of the learning curve.

In 94 patients undergoing internal fixation of the spine, a total of 542 screws were analyzed with XR (331 screws), CT (58 screws), or both (147 screws). Most PS were placed by the SSF (320 total, 59%) when compared to the ASC (187 total, 34.5%) and neurosurgical/orthopedic trainee (37 total, 6.5%). Of the 187 screws placed by the ASC, the "acceptable" or "expert proficiency" level was 94.7%. The rate of misplaced screws decreased

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from 12.5% in the first 80 screws to 3.4% in the last 240 screws. Similarly, there was a statistically significant difference in side-by-side screws placed by the SSF and ASC in the first 80 screws. However, this difference was not significant in the last 240 screws. No complications were seen from misplaced SSF screws.

Perspective: This study attempts to critically evaluate a key element of neurosurgical training, the resident's operative learning curve. The authors reviewed the placement of 542 screws, comparing the accuracy of a neurosurgical surgical spine fellow to that of a practicing attending neurosurgeon. The investigators graded screw placement using CT and scored their accuracy. They found that the learning curve at their center began to flatten out after 80 screw placements. Fortunately, no misplaced screws caused an injury to the patient.

We applaud the authors of this study; however, this report does have significant limitations. This is a single-center study that likely does not represent all surgical trainees. Furthermore, it raises concerns about surgical training inherent to academic centers. In modern surgical practice, misplaced screws are poorly tolerated. They present a significant risk to the patient, the health care system, as well as the surgical team. Other studies have shown that the incorporation of image-guided technology (CT-based and fluoro-based guidance systems) as well as intraoperative electromyography/screw testing may significant decrease the risk of pedicle breach and nerve root injury. We acknowledge, there is a learning curve for all procedures, but this only serves to emphasize the importance of a trainee's exposure to education outside of the operating room (OR). This highlights the need to further develop surgical simulation programs for trainees as well as fund and support technical training programs, such as cadaver courses.[1] The current study should serve as a stepping stone for further investigation in how we can safely improve resident surgical education.

Summary Written by: Angela Bohnen, MD

ADVERSE RADIATION EFFECT AFTER STEREOTACTIC RADIOSURGERY FOR BRAIN METASTASES: INCIDENCE, TIME COURSE, AND RISK FACTORS[10]

Study Question: What are the primary risk factors for symptomatic adverse radiation effects (AREs) after stereotactic radiosurgery (SRS) for brain metastases?

The authors of this study aim to evaluate the incidence, time course, and risk factors both for overall and symptomatic AREs following SRS for brain metastases. Currently, there exists no standard of care for treatment of brain metastases. Treatment options include surgical resection, whole brain radiation therapy (WBRT), and SRS. With regard to radiation, there currently does not exist a primary criterion for when patients should receive WBRT versus SRS. One of the primary risks of SRS is ARE or radiation necrosis. This risk varies depending not only if the lesion of interest has previously received radiation but also the dose of this prior treatment.

In an effort to better define, the risk factors associated with AREs after SRS, the authors evaluated 435 patients with 2200 brain metastases who received Gamma Knife SRS at UCSF. The authors calculated a rate of ARE of 5.4% with a total of 118 cases. Of these cases, 60% were symptomatic, and 85% occurred 3–18 months after SRS with a median of 7.2 months. For patients receiving prior SRS to the same lesion, the authors identified a 20% 1-year risk of symptomatic ARE as compared to patients with no prior treatment (3%), prior WBRT (4%) and concurrent WBRT (8%). For patients with up-front treatment with SRS, a 1-year probability of ARE was 3% for lesions with a maximum diameter of 1.1–1.5 cm and increased to 10% for lesions with a maximum diameter of 1.6–2.0 cm. In addition, with the multivariate analysis in lesions with a target volume >1 cm^3, ARE risk factors included a history of prior SRS, a renal primary, and patients with a connective tissue disorder.

Patients receiving SRS can present with both asymptomatic and symptomatic ARE. The authors effectively displayed risk factors associated with SRS with regard to ARE in a large patient cohort.

Perspective: This study provides insight into the primary risk factors for ARE in patients receiving SRS. In a patient population without a standard of care with regard to treatment, these risks factors are important in determining the role of other treatment options; most notable being surgical resection and WBRT. A primary limitation of this study is a lack of a control group with a WBRT cohort. In addition, the study is limited to a single institution. However, this study provides valuable insight into the importance of generating criteria for understanding where the risks of SRS may outweigh the benefits. In this study, there is a clear correlation between tumor volume and the risk of ARE after SRS. The authors displayed a significant increase in this risk with a maximum diameter even as small as 1.6 cm. In surgically accessible tumors, perhaps surgical resection should be considered as a treatment option. In patients with multiple lesions, perhaps there is a total tumor volume where WBRT puts patients at decreased risk as compared to SRS to each lesion. However, the potentially decreased risk of ARE with WBRT in patients with larger total tumor volume must be weighed against the increased risk of cognitive decline associated with WBRT as compared to SRS. The degree of pretreatment vasogenic edema and assessment if these lesions are "symptomatic" also needs to be taken into consideration. In addition, patients with a prior history of SRS may benefit from a combination of treatments such as surgical resection plus repeat SRS or perhaps WBRT to decrease the risk of symptomatic ARE. Overall, this paper provides insight into possible limitations of SRS based on such characteristics as tumor size and the degree of edema. Future prospective trials analyzing surgical resection, SRS and WBRT will help to generate an algorithm for utilizing these treatment modalities.

Summary Written by: Jonathan H. Sherman, MD

LONG-TERM FOLLOW-UP OF INCIDENTALLY DISCOVERED MENINGIOMA[3]

Study Question: What is the natural history of incidentally found meningiomas?

The authors[3] conducted a retrospective analysis of consecutive patients with incidentally found asymptomatic meningiomas referred to the authors' practice from January 1, 1991, to December 31, 1998, and followed prospectively for at least 10 years or until the endpoint of tumor growth or patient death was reached. Sixty-five patients (41 females and 24 males) who did not receive surgical or radiosurgical treatment at the time of diagnosis were included in the cohort.

The authors reported that the mean age at diagnosis was 66.6 years, with a range of 27–84 years. The most common conditions leading to imaging that discovered the meningiomas were a headache and dizziness (24.6%), neurological deficit (18.5%), and cognitive decline (10.8%). None of the symptoms leading to imaging were considered to be related to the tumors. The most common locations of the meningiomas were the skull base (38.5%), falx (23.1%), and convexity (20.0%). The average size at diagnosis was 2.36 cm, with a range of 0.6–7 cm. 26 (35.4%) meningiomas showed growth (defined as >2 mm progression in any diameter) occurring on average 2.96 years after diagnosis. Of the tumors that were ≤2 cm, 36.5% demonstrated progression, while 33.3% of tumors >2 cm showed growth on imaging. Life table analysis found that the 15-year progression rate of these meningiomas was 75%. There were no statistical differences in progression rates between males and females and between small and large tumors. Calcified tumors showed a statistical trend, but not statistical significance, toward lower growth rate.

Perspective: Meningiomas are the second most common primary intracranial tumor and the number of incidentally found asymptomatic meningiomas is rising.[8] These tumors, at diagnosis, are commonly followed with serial imaging. The authors retrospectively reviewed the natural history and growth rates of patients with incidentally diagnosed meningioma to elaborate to optimize the long-term management of these tumors. The slow growth pattern after 10 years of the incidentally found meningiomas in their cohort was similar to growth rates seen in other studies, and appropriately, the current protocol of closely following incidentally discovered meningiomas with radiographic imaging is sufficient. While previous studies have identified tumor size and calcification as predictors of growth, this study was likely underpowered to elaborate on factors that would identify those at high risk for long-term tumor growth. Similarly, other studies have found that >40% of recurrences occurred after 10 years of follow-up, albeit that findings from studies can vary depending on length and uniformity of follow-up. Thus, the high rate of long-term progression warrants a consideration of surgery for young patients, especially those with tumors that can be removed with low surgical risk. However, the study was likely underpowered to identify patient and tumor features, such as calcification and size, predictive of tumor growth.

Summary Written by: Panayiotis Pelargos and Isaac Yang, MD

BARROW RUPTURED ANEURYSM TRIAL: SIX YEARS RESULTS[12]

Study Question: Is there a difference in outcome for patients with ruptured aneurysms treated by coil embolization versus clip obliteration?

Five hundred patients with subarachnoid hemorrhage were enrolled in this randomized trial, with planned 10-year follow-up. Interim 6 years results are presented. All patients presenting to this single institution were assigned to surgical clipping or endovascular coiling, with the primary outcome measure being mRS >2. Analyses were performed based on an intention to treat, despite significant crossover from the endovascular-assigned patients to surgical clip treatment (38%). The Barrow Ruptured Aneurysm Trial (BRAT) study sought to provide a more representative set of patients with ruptured aneurysms compared to the International Subarachnoid Aneurysm Trial study, which has been critiqued for its lack of generalizability due to the inclusion of largely small, anterior circulation aneurysms.

The 3 years interim analysis was published in 2013,[11] and showed no difference in outcomes between patients treated with clipping versus coiling. Similarly, the updated results show no statistically significant difference in the primary endpoint between the two cohorts. However, there was a major difference between the two groups in the rate of crossover. Incomplete obliteration was quite rare in the clipping group (4%), with 4.6% requiring retreatment. Coil-assigned patients, on the other hand, had a 48% rate of incomplete obliteration and 16.4% retreatment rate. In spite of this, rebleeding was only seen in two cases.

Perspective: BRAT is one only a handful of studies directly comparing the results of coil embolization and surgical clipping of intracranial aneurysms, and it is unique among these by its broader case distribution and crossover rate.[7] Theoretically, patients in this trial were offered the best of both words, with "super specialized" neurovascular surgeons offering either treatment.[5] The higher than expected crossover rate may be due to a referral bias toward more complex aneurysms though an institutional bias cannot be ruled out in this single center study.

Incomplete aneurysm obliteration and the possibility of rerupture have long been a concern with aneurysm coiling. Their rates of incomplete obliteration from both arms are in line with the previous series for clipping[13] and coiling.[9] The authors of the current work, as well as the associated editorial published in the same journal issue,[6] conclude that despite the higher rate of residual and recurrence with aneurysm coiling, the rerupture rate is very small, thus making this difference of uncertain clinical significance. Despite the large number of patients enrolled in this study, it was still underpowered to make such a conclusion. However, other studies do shed light on this issue. The Cerebral Aneurysm Rerupture After Treatment study showed clearly that rerupture of treated aneurysms can have major consequences.[4] Since the majority of these were early reruptures, it seems logical that we should remain cautious when electing for a treatment which is unlikely to be immediately definitive.

Just as the last interim report of the BRAT study showed, the most recent data confirm that the initial differences in outcome have now lost statistical significance, suggesting equivalency. As any comprehensively trained vascular neurosurgeon knows well, individual aneurysm treatment deserves a more nuanced approach. The minute difference in technique, patient presentation, and a variety of aneurysm characteristics can easily overcome the inherent differences between coiling and clipping.[6] Ultimately, what matters to the patient being treated is not the outcome of a randomized study but what the individual surgeon can offer a patient at their institution and with their abilities. Maintaining excellence with both treatment modalities, whether by the same practitioner or partners at an institution, with appropriate clinical equipoise, is paramount.

Summary Written by: Visish M. Srinivasan and Edward A. M. Duckworth

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Conflicts of interest

There are no conflicts of interest.

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