

Quantifying the utility of a multidisciplinary neuro-oncology tumor board

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OBJECTIVE There has been limited research on the efficacy of multidisciplinary tumor boards (MDTBs) in improving the treatment of patients with tumors affecting the nervous system. The objective of the present study was to quantify the utility of MDTBs in providing alternative diagnostic interpretations and treatment plans for this patient population.

METHODS The authors performed a prospective study of patients in 4 hospitals whose cases were discussed at MDTBs between July and November 2019. Patient demographic data, diagnoses, treatment plans, and eligibility for clinical trials were recorded, among other variables.

RESULTS A total of 176 cases met eligibility criteria for study inclusion. The majority (53%) of patients were male, and the mean patient age was 52 years. The most frequent diagnosis was glioblastoma (32.4%). Among the evaluable cases, MDTBs led to 38 (21.6%) changes in image interpretation and 103 (58.2%) changes in patient management. Additionally, patients whose cases were discussed at MDTBs had significantly shorter referral times than patients whose cases were not discussed ($p = 0.024$).

CONCLUSIONS MDTB discussions led to significant numbers of diagnostic and treatment plan changes as well as shortened referral times, highlighting the potential clinical impact of multidisciplinary care for patients with nervous system tumors.

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KEYWORDS neuro-oncology; neurosurgery; oncology; decision-making

MULTIDISCIPLINARY treatment is increasingly common in the management of oncological conditions as the care of cancer patients continues to become more complex, necessitating the coordinated efforts of a diverse team of medical specialists.^{1–4} Multidisciplinary tumor boards (MDTBs), consisting of meetings in which experts from different fields discuss patient cases and offer treatment recommendations, is one way to achieve such care coordination. Previous research has examined the efficacy of MDTBs in specialties such as gynecological oncology, otolaryngology, and urology and found that these meetings significantly influence diagnostic interpretations and treatment plans for cancer pa-

tients.^{1,5–9} Investigations into the efficacy of MDTBs have also been conducted for rectal cancer patients, patients suffering from upper-gastrointestinal malignancies, and pediatric cancer patients, yielding similar findings, suggesting that MDTBs lead to significantly altered treatment recommendations for patients.^{10–12} However, while the use of neuro-oncology MDTBs is frequent and widespread, to the authors' knowledge research has yet to directly measure the efficacy of MDTBs in positively influencing the diagnosis and treatment of patients with cancer affecting the nervous system.

The purpose of the present study was to quantify the utility of a weekly neuro-oncology MDTB by determin-

ABBREVIATIONS MDTB = multidisciplinary tumor board; NP = nurse practitioner; PA = physician assistant.

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ing to what extent these meetings influence diagnosis and treatment within this patient population. The primary outcome of interest was whether the MDTB discussion led to changes in patient treatment plans, such as the additions of referrals, recommendations for further diagnostic workups, and any additional surgical, medical, and radiation treatments or clinical trial recommendations. We also tracked whether MDTB discussions led to changes in imaging interpretations. Additionally, we tracked the time from MDTB referral to eventual clinic visit for patients discussed at MDTBs relative to those who were not discussed. We hoped that our study would validate the perceived utility of MDTBs by providing quantitative data supporting the notion that these meetings directly influence patient management.

Methods

This prospective study had Institutional Review Board approval (IRB number 00216557). A total of 14 consecutive, weekly MDTB meetings held at 4 different hospitals within a single health system were analyzed between July 29, 2019, and November 18, 2019. At our institution, cases referred for MDTB discussion are typically those in which patients have had a tumor recurrence, cases in which there is an element of diagnostic uncertainty, and cases for which there are unclear imaging findings, such as a clinician having difficulty differentiating between tumor progression and pseudoprogression. Patient demographic data and clinical information, including diagnosis, were prospectively collected in real time by 3 study coinvestigators (A.M.K., C.G.R., and D.O.K.). Data points were compared between coinvestigators after each MDTB meeting to ensure accuracy and consistency. All patients discussed at the MDTB meetings were included in our study cohort; there were no other inclusion or exclusion criteria in the present study. The number of tumor board attendees from different medical teams and the extent of their participation in the meeting were also noted. Medical specialties represented at the meetings included neuro-oncology, neuroradiology, neurosurgery, radiation oncology, pathology, medical oncology, hematology-oncology, neurology, and ophthalmology. Physician assistants (PAs) and nurse practitioners (NPs) were also present.

Prior to each meeting, patient cases were collected in the form of a spreadsheet collated weekly by an administrative assistant within the neuro-oncology department. Participating providers were asked to provide basic patient demographic data, a presumed or known diagnosis, concerns to be discussed, and a tentative treatment plan. This information was used to record a “preconference” diagnosis and treatment plan for each patient discussed at the meeting. Preconference diagnoses and treatment plans reflected the opinions of the referring attending physician based on information available at the time of the MDTB referral. Each patient was screened by a neuro-oncology fellow prior to the patient’s case presentation at the MDTB meeting to ensure that adequate information was available to effectively present the patient at the scheduled session. In cases for which data were needed

in addition to those presented at the initial MDTB meeting in order to make a decision regarding treatment or management, the MDTB ordered new diagnostic testing. These case patients were then routinely re-presented at a later meeting, upon completion of their new diagnostic testing. Following the discussion of patient cases, the “postconference” diagnosis and treatment plan were recorded. For the purposes of our study, treatment plan changes were defined as follows: addition of new diagnostic workup, new referrals, or changes in surgical treatment, medical treatment, radiation treatment, or clinical trial recommendations. A change in surgical, medical, or radiation treatment included either the addition or removal of therapies from the patient’s pre-MDTB treatment plan. Clinical trial changes involved either referring patients to or disenrolling them from clinical trials discussed prior to the MDTB. Any change in the interpretation of diagnostic imaging was also recorded. Importantly, the vast majority of cases reviewed by our neuro-oncology tumor board involved review of radiological rather than pathological images. At our institution, a separate molecular tumor board specializes in handling cases in which clinicians request multidisciplinary assistance with interpreting pathological results.

Statistical Analysis

Data were collected using Excel 2016 (Microsoft Corp.) and statistical analysis was conducted using SPSS version 25.0 (IBM Corp.). The Shapiro-Wilk test was used to test for normality, and the Mann-Whitney U-test was used to assess differences in referral times. For the Mann-Whitney U-test, difference in location (distributions of the 2 samples being tested) was defined as the median of the difference between a sample referral time from the MDTB cohort and a sample referral time from the non-MDTB cohort; $p \leq 0.05$ was considered statistically significant, and p values were reported as two-sided.

Results

Patient Demographics

Data were collected from 14 MDTB meetings, each 90 minutes in scheduled duration. The 14 MDTB meetings had an actual mean duration of 89.93 minutes, with an SD of ± 15.10 minutes. The shortest tumor board meeting within our study period lasted 73 minutes, while the longest meeting within our study period lasted 124 minutes. In total, 176 patients were discussed, with a median of 12.5 patients (range 9–16 patients) being discussed at each meeting. Each patient case discussion lasted a mean of 7.2 ± 2.8 minutes (range 3–16 minutes). The demographic data of our patient cohort are summarized in Table 1. The majority (53%) of the 176 patients were male, with a median and mean patient age of 52 years. The 5 most frequent diagnoses in our patient cohort were glioblastoma (32.4%); diffuse astrocytoma, WHO grade II (7.4%); anaplastic astrocytoma, WHO grade III (7.4%); oligodendroglioma, WHO grade II (5.7%); and anaplastic oligodendroglioma, WHO grade III (4.5%). Diagnoses with 1 patient each are listed in Supplementary Table 1.

TABLE 1. Patient demographics (n = 176)

| Characteristic | Value |
|---|-------------|
| Sex | |
| Male | 93 (52.8) |
| Female | 83 (47.2) |
| Age in yrs, mean \pm SD | 52 \pm 16 |
| Diagnosis | |
| Glioblastoma | 57 (32.4) |
| Diffuse astrocytoma, WHO grade II | 13 (7.4) |
| Anaplastic astrocytoma, WHO grade III | 13 (7.4) |
| Oligodendroglioma, WHO grade II | 10 (5.7) |
| Anaplastic oligodendroglioma, WHO grade III | 8 (4.5) |
| Brain metastasis | 8 (4.5) |
| Atypical meningioma, WHO grade II | 7 (4.0) |
| Brainstem glioma, NOS | 5 (2.8) |
| Neurofibromatosis type 2* | 4 (2.3) |
| Meningioma, grade I | 4 (2.3) |
| Gliosarcoma | 3 (1.7) |
| Low-grade glioma (imaging diagnosis) | 3 (1.7) |
| Anaplastic meningioma, grade III | 3 (1.7) |
| Cranial pleomorphic spindle cell sarcoma | 3 (1.7) |
| Neurofibromatosis type 1† | 2 (1.1) |
| Anaplastic pleomorphic xanthoastrocytoma, WHO grade III | 2 (1.1) |
| Chondrosarcoma | 2 (1.1) |
| Optic nerve glioma | 2 (1.1) |
| Primary CNS lymphoma | 2 (1.1) |

NOS = not otherwise specified.

Values are the number of presented case patients (%) unless otherwise indicated.

* 3 cases of meningioma, 1 case of meningioma with concomitant schwannoma.

† 1 case of diffuse astrocytoma, 1 case of optic nerve glioma.

Attendance and Participation

On average, each meeting had a median of 25 (range 21–31) total attendees. Attendance and participation at MDTBs by medical specialty is shown in Table 2. The neuro-oncology specialty had the highest representation, with a median of 3 faculty neuro-oncologists present at each meeting. At any given MDTB, there were attendings from at least 3 different medical specialties present for each case discussed. Neuro-oncology also had the highest number of trainees present at MDTBs, with a median of 3 fellows present at each meeting. A median of 7 PAs and NPs were present at each MDTB meeting, representing a variety of specialties, including neuro-oncology, radiation oncology, and neurosurgery. Neuro-oncology presented the majority (61.4%) of cases and participated in the discussions of 98.9% of cases.

Outcomes

MDTB meeting outcomes are displayed in Table 3. Overall, among the 176 cases in this study, the meetings led to changes in image interpretation in 21.6% of cases

and changes in patient management in 58.5% of cases. Data were missing for imaging interpretation for 1 (0.6%) patient and for clinical management for 5 (2.8%) patients. Clinical trials were discussed for 69 (39.2%) cases, and 47 (26.7%) of these cases included patients who were eligible for clinical trials.

Figure 1 summarizes changes in patient clinical management following MDTB case discussions. Changes in surgical planning were the most common (n = 23), followed by recommendations for new diagnostic testing (n = 19) and changes in medication (n = 15), clinical trial referral (n = 10), new provider referral (n = 9), or radiation planning (n = 4). Of the 19 patients for whom additional diagnostic testing was recommended, a change in medical management was also recommended for 4 of these patients and a new surgical plan for 2 patients, and 1 patient was also referred for a new clinical trial. Among the 9 patients for whom a new provider referral was recommended, new diagnostic testing was recommended for 3 patients, and a change in surgical plan was also recommended for 1 patient.

Among the 14 patients who received a referral to a different provider through the MDTB, we were able to track the median time from MDTB presentation to the patient meeting with their new provider in 10 patients. The median referral time for this MDTB cohort was 7 days (range 2–22 days). To determine referral times for patients who were not referred through the MDTB, we calculated the median lag time for each new referral to an MDTB-associated neuro-oncologist or neurosurgeon at our institution for the calendar year 2019. Median provider lag times were determined for 6 tumor neurosurgeons and 4 neuro-oncologists (consisting of a total of 2703 individual patient referral times). Our institution catalogs date of referral in a centralized administrative database, and lag times were calculated from this centralized date of referral to the date of provider appointment. A composite median of these lag times among all 10 providers was calculated to be 16 days (range 4–128 days). Patients who were not referred through MDTB had a significantly longer lag time compared to patients who were referred through the MDTB (p = 0.024, difference in location = 7.58 days, 95% CI 1.00–22.00 days).

Discussion

A multidisciplinary approach to cancer care has many theoretical benefits that have been detailed in the literature, including improved patient survival, more accurate and complete preoperative staging, a greater likelihood of patients receiving evidence-based care, and improved access to clinical trials.^{13–16} Recently, research has focused on determining whether evidence exists for the actual clinical impact of MDTBs in the care of cancer patients. A study by Kurpad et al. found that genitourinary malignancy MDTB meetings led to changes in diagnosis or treatment for 38% of the patients in their study, emphasizing the utility of such a multidisciplinary approach.⁵ A 2010 study by Wheless et al. investigated the efficacy of an MDTB in altering diagnoses, tumor staging, and treatment plans for head and neck tumor patients. The investigators found that MDTBs led to changes in diagnostic and treatment deci-

TABLE 2. MDTB meeting attendance and participation

| Attendees | | Participants | |
|---|--------------------------------|--------------------------|-------------------------------------|
| Specialty | Median No. per Meeting (range) | Team Presenting Case | Percentage of Cases (no.) (N = 176) |
| Neuro-oncology | 3 (1–5) | Neuro-oncology | 61.4% (108) |
| Neuroradiology | 1 (1) | Neurosurgery | 30.7% (54) |
| Neurosurgery | 1 (0–4) | Medical oncology | 3.5% (6) |
| Radiation oncology | 1 (0–3) | Radiation oncology | 2.8% (5) |
| Pathology | 0 (0–1) | General neurology | 1.1% (2) |
| Other* | 0 (0–2) | Ophthalmology | 0.6% (1) |
| Trainees (fellows, residents) and Staff | | Teams Joining Discussion | |
| Neuro-oncology | 3 (2–4) | Neuro-oncology | 98.9% (174) |
| Neurosurgery | 2 (1–3) | Neurosurgery | 58.5% (103) |
| Radiation oncology | 1 (0–2) | Neuroradiology | 33% (58) |
| PAs and NPs | 7 (3–8) | Radiation oncology | 33% (58) |

* Medical oncology, general neurology, ophthalmology.

sions for 27% of patients, further emphasizing the important role of MDTBs in another cancer patient population.¹ Researchers at Seoul National University conducted a similar study assessing the efficacy of an MDTB conference in influencing care within a gynecological oncology patient population. This study demonstrated that the MDTB led to changes in diagnostic workup for 23.5% of patients, with a treatment plan change rate of 27.1%.⁶ Though much research in a variety of oncological specialties has been aimed at gauging the clinical impact of MDTBs by quantifying diagnostic and treatment plan changes, no such studies have yet been undertaken to assess the efficacy of MDTBs for nervous system tumors. A study by Snyder et al., using a cross-sectional descriptive survey, sought to determine how neuro-oncology MDTBs at academic institutions across the US are constructed and managed.⁴ While survey responses demonstrated consistency in core member participation, types of cases discussed, and the perceived value of neuro-oncology MDTBs, the investigators noted that there was high variability in the amount of time participants spent preparing for MDTB meetings and

in methods of recording recommendations.⁴ In the present study we sought to supplement this prior research regarding the value of neuro-oncology MDTBs by directly quantifying the extent to which such meetings lead to changes in patient management and treatment plans.

The results of our study demonstrate that the meetings of the neuro-oncology MDTB examined in this study led to a large number of changes in treatment plans, with 58.2% of presented cases having a subsequent change in management. These results support the notion that neuro-oncology MDTB discussions are influential in affecting clinically relevant patient care. Importantly, our conclusions are in concordance with previous studies of MDTBs in other fields, which demonstrates the influence of MDTBs on decision-making in the clinical management of cancer patients.^{1,5,6,10–12} In addition to changes in management, our results also demonstrate that neuro-oncology MDTB discussions led to changes in imaging interpretation in 21.6% of cases. This finding is particularly important in neuro-oncology where, beyond measurable changes in contrast-enhancing tumor volumes, qualitative imaging interpretation often helps define progressive disease.¹⁷ Our findings emphasize that neuro-oncology MDTB conferences are likely an important avenue to integrate clinical and imaging information to guide future patient care. Regarding attendance and participation, our finding that neuro-oncology, neurosurgery, neuroradiology, and radiation oncology teams were consistent participants at MDTB meetings concurs with the results of Snyder et al., whose survey responses demonstrated that these specialties formed the core membership of neuro-oncology MDTBs.⁴ The extent of participation of these specialists seemed to reiterate the role of neuro-oncologists as a hub to connect medical and procedure-oriented disciplines in the care of cancer patients. As noted by Snyder and colleagues, focusing future research on examining MDTB group dynamics, such as how meetings are managed and the process by which different specialties provide input during the meetings, may be crucial to optimizing future patient care and outcomes.⁴

TABLE 3. MDTB meeting outcomes (n = 176)

| Outcome | No. of Cases (%) |
|----------------------------------|------------------|
| Change in imaging interpretation | |
| Yes | 38 (21.6) |
| No | 137 (77.8) |
| Missing | 1 (0.6) |
| Change in management | |
| Yes | 103 (58.5) |
| No | 68 (38.6) |
| Missing | 5 (2.8) |

Change = difference in imaging interpretation or management/treatment plan for any given case patient after MDTB presentation; missing = missing image interpretation or clinical management data.

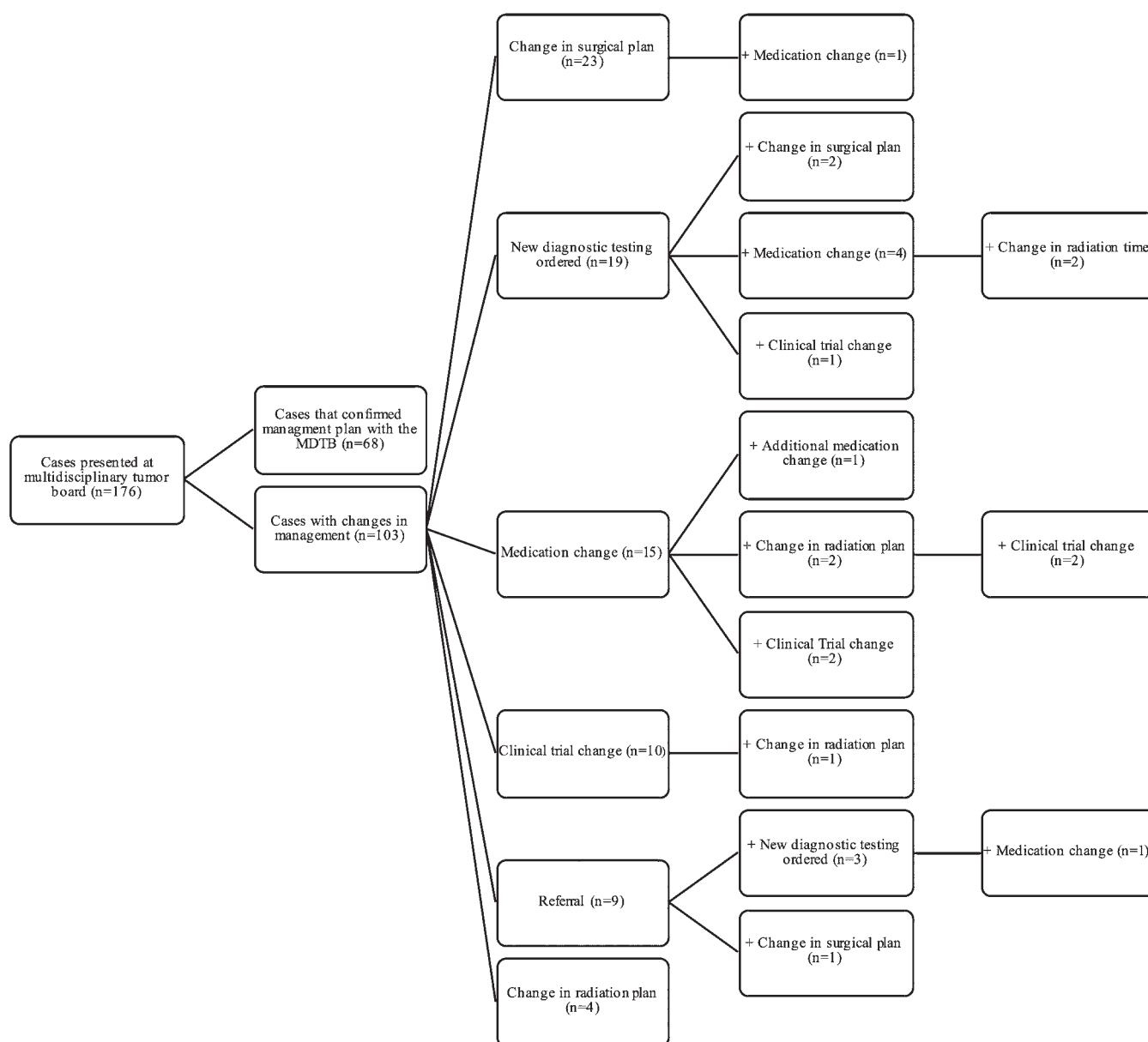


FIG. 1. Chart summarizing MDTB case patient outcomes in the present study.

Notably, patients referred through the neuro-oncology MDTB had significantly shorter wait times between referral and clinic visit compared with patients who were not referred through the MDTB. A possible explanation for this observation is that MDTB meetings in general discuss a high proportion of complex cases in patients who often require more urgent care than patients whose cases are not selected for MDTB scrutiny. An alternative explanation is that patients deemed to require more immediate intervention by the MDTB may preferentially receive expedited care compared with non-MDTB counterparts with similarly critical health issues. Further research is needed to determine the importance of referral times in ensuring optimal outcomes for patients discussed at MDTBs.

Considering that the present study was conducted within a health system containing a large, academic medical center, an important avenue for future research could focus on examining how MDTBs may be beneficial to smaller hospitals. At our institution, smaller satellite hospitals participate and present their own patient cases both in person and remotely (amid the present COVID-19 social-distancing guidelines and travel restrictions) at our main academic institution's MDTB meetings. Future research could focus on the effects of increasing the access that smaller hospitals have to MDTBs based at larger academic medical centers and determining if such efforts lead to improved patient outcomes.

There are various limitations to the present study. First, this study did not examine patient clinical outcomes fol-

lowing their presentation at MDTB. Thus, while we are able to confirm that the MDTBs we studied led to a large number of changes in imaging interpretation and management, we are unable to comment on whether such changes directly led to improved outcomes, such as increased progression-free or overall survival. Second, we did not collect granular data on the exact change of imaging re-interpretation, such as categorizing imaging findings as pseudoprogression versus true progression in patients with a history of glioma. Last, our study only examined patients at 4 hospitals within a single health system, and thus our results may have limited generalizability to other hospitals or medical centers. Acknowledging these limitations, our study was to our knowledge the first to examine the efficacy of MDTBs in the management of patients with nervous system tumors, and our results confirm the significant clinical impact of MDTBs as measured by changes in imaging interpretation and treatment management for these cancer patients.

Conclusions

Our study is probably the first to quantify the efficacy of MDTBs in the management of patients with tumors of the nervous system. Our results demonstrate that neuro-oncology MDTBs led to a large number of changes in image interpretations (21.6%) and treatment plans (58.2%), emphasizing the clinical importance of MDTB discussions in verifying diagnostic conclusions and influencing treatment for cancer patients. Additionally, patients whose cases were discussed at MDTB meetings had significantly shorter referral times than patients at the same institutions whose cases were not discussed.

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Author Contributions

Conception and design: Khalafallah. Acquisition of data: Khalafallah. Analysis and interpretation of data: Khalafallah, Jimenez. Drafting the article: Khalafallah, Jimenez. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Mukherjee. Statistical analysis: Khalafallah, Jimenez. Study supervision: Mukherjee, Khalafallah.

Supplemental Information

Online-Only Content

Supplemental material is available with the online version of the article.

Supplementary Table 1. <https://thejns.org/doi/suppl/10.3171/2020.5.JNS201299>.

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