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Feasibility of simultaneous meningioma resection and cesarean section: A systematic review and a technical case presentation

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1. Introduction

Even though meningiomas are the most common intracranial tumoral entity and the gender relationship is double the amount of cases in women, the incidence of these tumors in the pregnant population is merely 2.6/100.000 pregnancies,[1] due to the low percentage of incidence there is a lack of standardized guidelines for neurosurgical treatment and management of this kind of cases.[2,3]

Pregnancy-related symptomatology such as vomit, nausea, and headaches may be confused with increased intracranial pressure (ICP) symptoms, this similarity in clinical presentation makes correct diagnosis of ICP due to tumoral mass challenging and delays the treatment.[4]

When correctly diagnosed, these rare cases clinical and surgical management decisions should be based on a multidisciplinary team of neurosurgeons, gynecologists, anesthesiologists, and neonatologists.[5]

Here we present a systematic review of the current literature of same-session meningioma resection surgery and cesarean section as well as a example technical case of our own, surgical indications and reasoning behind the performance of these approaches, as well as results and future indications.

2. Materials and methods

A systematic literature review using PubMed, Scopus, and Web of Science was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) criteria with terms and specialized search including MeSH keywords.

("Meningioma" OR "Intracranial Meningioma" OR "Intracranial Meningiomas" OR "Meningioma, Intracranial" OR "Meningiomas, Intracranial" OR "Intraorbital Meningioma" OR "Intraorbital Meningiomas" OR "Meningioma, Intraorbital" OR "Intraventricular Meningioma" OR "Intraventricular Meningiomas" OR "Meningioma, Intraventricular" OR "Malignant Meningioma" OR "Malignant Meningiomas" OR "Meningioma, Malignant" OR "Meningiomas, Malignant" OR "Meningiomas, Multiple" OR "Meningioma, Multiple" OR "Multiple Meningioma" OR "Multiple Meningiomas" OR "Meningotheliomatous Meningioma" OR "Meningioma, Meningotheliomatous" OR "Meningotheliomatous Meningiomas" OR "Microcystic Meningioma" OR "Meningioma, Microcystic" OR "Microcystic Meningiomas" OR "Olfactory Groove Meningioma" OR "Meningioma, Olfactory Groove" OR "Papillary Meningioma" OR "Meningioma, Papillary" OR "Meningiomas, Papillary" OR "Papillary Meningiomas" OR "Parasagittal Meningioma" OR "Meningioma, Parasagittal" OR "Parasagittal Meningiomas" OR "Posterior Fossa Meningioma" OR "Meningiomas, Posterior Fossa" OR "Posterior Fossa Meningiomas" OR "Psammomatous Meningioma" OR "Meningioma, Psammomatous" OR "Psammomatous Meningiomas" OR "Secretory Meningioma" OR "Meningioma, Secretory" OR "Meningiomas, Secretory" OR "Secretory Meningiomas" OR "Sphenoid Wing Meningioma" OR

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"Meningioma, Sphenoid Wing" OR "Meningiomas, Sphenoid Wing" OR "Sphenoid Wing Meningiomas" OR "Benign Meningioma" OR "Benign Meningiomas" OR "Meningioma, Benign" OR "Meningiomas, Benign" OR "Cerebral Convexity Meningioma" OR "Cerebral Convexity Meningiomas" OR "Meningioma, Cerebral Convexity") AND ("Abdominal Deliveries" OR "Deliveries, Abdominal" OR "Caesarean Section" OR "Caesarean Sections" OR "Abdominal Delivery" OR ″C-Sections (OB)" OR "Postcesarean Section" OR "Pregnancy" OR "Pregnancies" OR "Gestation")

The inclusion criteria were for case reports, case series, cohorts, and original articles, where meningioma pregnant patients were treated with surgical excision of the tumor followed by a cesarean section or vice-versa in the same surgical act. The authors did not include literature reviews, meta-analyses, editor letters, cases of vaginal delivery or other types of articles treating meningiomas and cesarean sections in different surgical times, also, we excluded other type of tumors treated simultaneously with cesarean section. Additionally, we include non-English papers that were translated by bilingual authors in the case of articles written originally in Spanish and artificial intelligence chatbot ChatGPT as an academic translator in case of other languages such as Russian. A total of 974 articles were found, where 422 were removed due to duplicity, subsequently, 552 records were screened until remained 44 reports assessed for eligibility, from them only 7 studies completed with the inclusion criteria (Fig. 1). MGO and UTV performed all the identification and screen of the studies, and FF was the main consultant.

2.1. Case presentation

A 40-year-old female, presented to the gynecology department at our institution referring headaches, difficulty moving her left extremities and abdominal pain with the thought of these symptoms being pregnancy-related due to a 21-week delay in her usual menstruation dates, due to these symptoms the neurosurgical department was consulted with suspicion of a neurological problem rather than an obstetric situation.

On the initial physical examination, a Glasgow Coma Scale (GCS) of 14/15 points was reported and left mild hemiparesis with physical strength of 4/5 on the Daniels scale, with this results the neurosurgery team recommended a brain computerized tomography (CT) scan. In CT scan a well-defined intracranial mass, isodense to brain parenchyma with significant perilesional edema located on the frontal lobe region was discovered, midline shift and radiologic signs of increased intracranial pressure were also noted. Additionally, a fetal ultrasound was done in order to confirm a pregnancy on demand of the mother, showing a fetus with an estimated gestational age of 28 weeks.

After confirmation of pregnancy and under suspicion of a meningioma, a magnetic resonance imaging (MRI) was performed where a mass centered in the anterior fossa, right paramedian, with difficult distinction regarding its intra- or extraxial origin, mixed with a centrally hyperintense solid component and a peripheral cystic component was showed. The mass appeared slightly heterogeneous and exhibited hypointensities on the T2 sequence corresponding to hemorrhagic traces, as confirmed by previous CT scan. Its dimensions were 68 x 50 × 55 mm (anteroposterior x transverse x craniocaudal), with a volume of 97.2 cc. The mass was associated with significant perilesional edema, resulting in mass effect with a 20 mm midline shift to the left and compression of the lateral ventricles (Fig. 3A–C). A right frontal giant meningioma was diagnosed.

On the next day morning patient neurological status deteriorated to a GCS of 12/15 (O2, V4, M6) and emergent surgery was planned in the same morning.

2.1.1. Surgical planning and approach

A multidisciplinary team was formed inside the operating room, consisting of 1 attending neurosurgeon, 3 neurosurgery residents, 1 attending anesthesiologist, 1 anesthesiology resident, 2 scrub tech nurses (1 dedicated for each one of the surgical teams), 2 gynecologists, and 2 circulating nurses (Fig. 2).

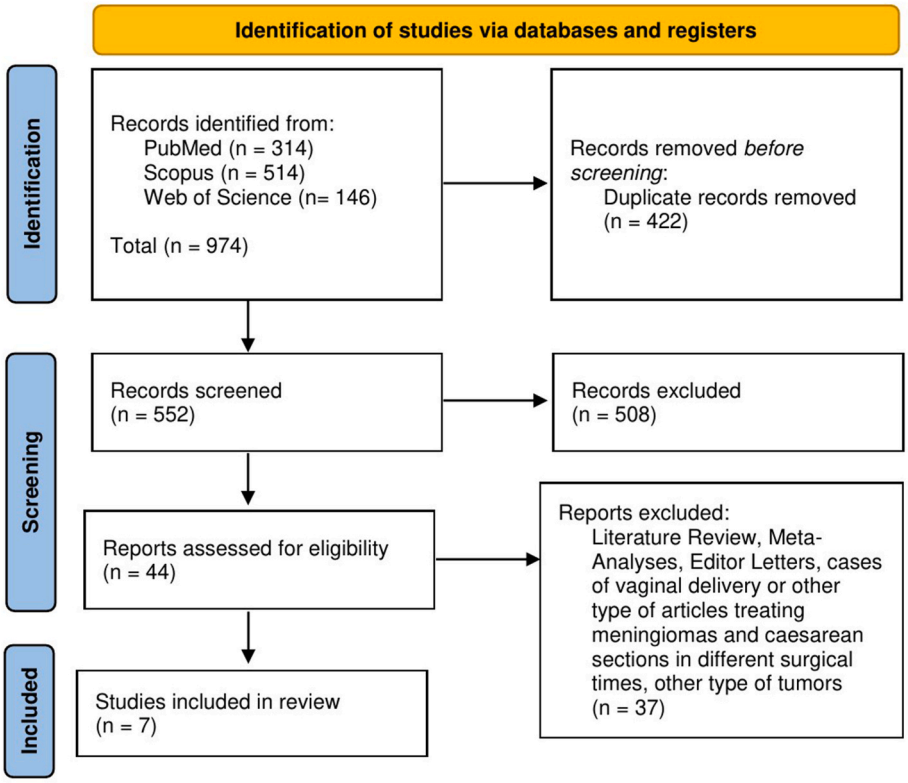

Fig. 1. PRIMSA Flow chart.

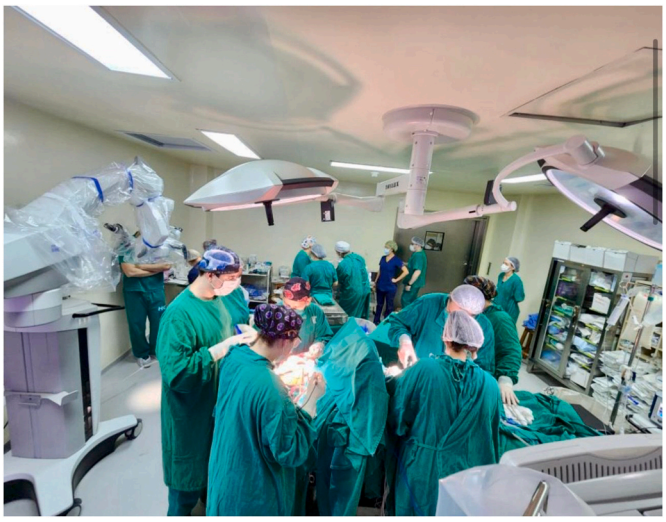

Fig. 2. Multidisciplinary team during simultaneous approach, to the left neurosurgery residents can be seen performing the craniotomy and to the right the gynecology team.

Due to the emergent characteristics of the case, a standard decompressive craniectomy was planned to prevent brain herniation. During the preparation of the surgical fields, the possibility of a cesarean section was considered in case of necessity due to possible fetal distress, so both the cranial and abdominal areas were sterilized.

During the drilling stage of the neurosurgical approach, the gynecology team noted fetal bradycardia with a rate of 100 bpm, leading to the decision to perform a cesarean section simultaneously with the approach, the continuation of the neurosurgical approach proceeded without issues. A gross total resection of the tumoral mass was achieved (Simpson Grade 1), and a decompressive craniectomy was done because cerebral edema prevented from immediate replacement of the bone flap. Histopathological studies showed a meningothelial meningioma (WHO Grade I).

Post-surgical evolution was uneventful. Patient was discharged 9 days post-surgery with a GCS of 15/15, improvement in her hemiparesis, and plans for future cranioplasty. Upon follow-up 6 months later, the patient continues to have a favorable evolution, without hemiparesis.

2.1.2. Birth and neonatal evolution

A 28-week-old male baby was born cyanotic with an APGAR score of 4. The baby was promptly intubated and sent to the neonatal intensive care unit where he stayed for 10 weeks. During this period, no complications were noted, and the neonate had a favorable evolution. Patient was discharged active, reactive, and without complications, malformations, or pathologies.

3. Discussion and results

Theories explaining the implication of sexual hormones and their relationship with rapid meningioma growth during pregnancy have been published reporting that the expression of progesterone, estrogen and androgen receptors is present in 88 %, 40 % and 39 % of meningiomas respectively.[6–8] Nevertheless, others suggest that tumoral growth is caused by a hypervolemic state in pregnancy with an altered osmoregulation system and that these previous hormonal theories fail to explain the reasoning behind reduction of tumoral size after birth, these contradictions cause the phenomenon to remain unexplained in totality.[9–11]

Giraldi et al even propose that meningiomas related to pregnancy should be considered a different entity of their own, supported by the fact that almost 60 % of these tumors are positive to prolactin receptors, which can influence directly of tumor growth during gravidity periods,[12,13] this idea is supported by the fact that during the second and third trimester of pregnancy, prolactin levels increase in an accelerated manner and, in most cases, at the same time accelerated tumor growth is observed.[3,14,15]

Similar to our case, misdiagnosis can occur in pregnant women with brain tumors due to overlapping symptoms like nausea, headaches, vomiting (which may be attributed to pregnancy or hyperemesis gravidarum), and vision problems (potentially mistaken for preeclampsia).[5,16]

Brain tumor surgery and especially emergent surgery during pregnancy entails a complex decision-making algorithm, in which multidisciplinary teams composed of neurosurgeons, gynecologists, pediatricians, neonatologists and anesthesiologists are cardinal as additional considerations and possibilities need to be assessed compared to an isolated neurosurgical approach. Tumor characteristics such as peritumoral edema, location, growth evolution and patient's neurological status have to be taken into consideration at the same time as pregnancy development and stage as surgery during the end of the second trimester minimizes anesthesia associated risks for the fetus.[5,17,18]

According to Somma et al, in instances where a brain tumor is diagnosed during the initial trimester of pregnancy, one consideration is therapeutic abortion. If this is not pursued, surgical intervention may be deferred until the conclusion of the second trimester. However, a distinct paradigm arises when a patient exhibits progressive neurological deterioration, necessitating emergency surgical resection.

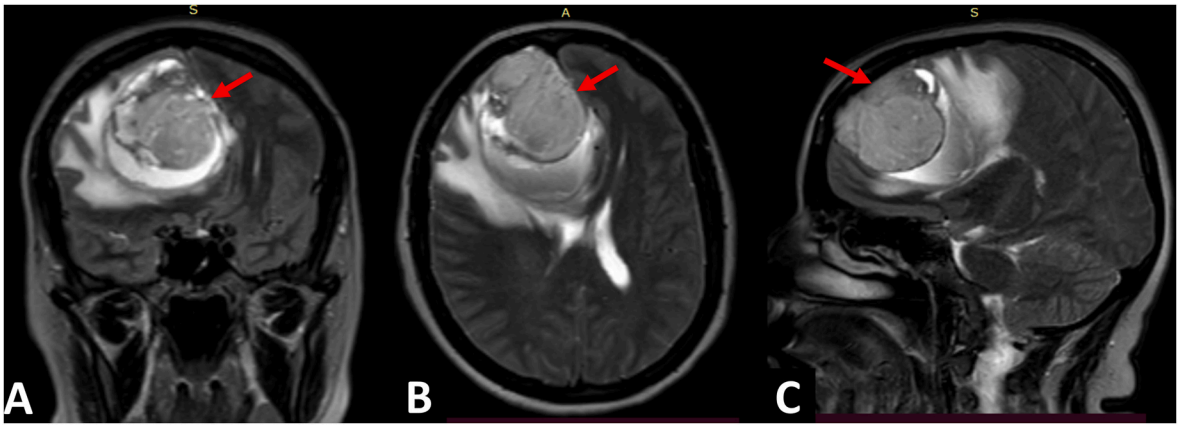

Fig. 3. T2-Weighted MRI showing a giant meningioma centered in the anterior fossa with severe perilesional edema, 20 mm midline shift, ventricular compression and radiological signs of severe intracranial hypertension.

Regardless of malignancy, surgical resection is the preferred management strategy for both malignant and benign tumors that manifest symptoms. During the second and third trimesters of pregnancy, scheduled neurosurgery can be undertaken post-34 weeks, affording the fetus higher survival probabilities. Administration of steroids to enhance pulmonary maturation and prevent intracranial hemorrhage is advised during this period.[5]

Neurosurgical intervention to resect an intracranial lesion during pregnancy carries the risk of induced hypocapnia, hypoxia and hypotension, all of which can greatly impact the fetus in addition, these potential risks can lead to recommend termination of the pregnancy in addition to minimizing brain edema and hypervolemic state and prevent the fetus to be exposed to deleterious compounds such as osmotic agents, antiepileptics and high-dose corticosteroids, widely used during neurological surgery.[19–22]

However, as in our case, when emergency resection is needed, fetal monitoring during surgery can help to assess fetal health and increase chances of prolonging the pregnancy, however signs of fetal distress may lead to emergency cesarean section.

To the best of the authors knowledge only 7 other cases of simultaneous management regarding cesarian section and meningioma resection were published (Table 1).[16,21–26] The mothers average age was 30 (16–41) years, with no similar pregnancy characteristics or meningioma localization between each other. The average gestational week was 31.8 (26–39) weeks, and, it is important to note that 4/7 cases present symptoms that can be easily misunderstood with pregnancy-related symptomatology such as headaches, nausea, and vomiting,[16,23,24,26] our patient presented the same symptoms. Six cases had cesarian section followed by craniotomy,[21–25] in the present case the authors called for a cesarean section when the gynecological surgical team denoted fetal bradycardia, the same indication was reported by Johnson et al after treating a 34-old pregnant with a bifrontal meningioma.[26] As in the present case, 6/7 cases reported that fetal outcome was favorable, in the case reported by Johnson et al a 26-week neonate died on the 14th day due to perinatal asphyxia, this outcome is in line with what is currently known about the timing of surgery during pregnancy, with the 27th week of gestation being the inferior time limit for pre-term deliveries accompanied by neurosurgical interventions with increased chances of survival for the fetus.[12,26]

4. Conclusion

Same-session meningioma resection and cesarean section can be a plausible last resort for pregnant patients presenting rapid neurological

Table 1
Reports from simultaneous meningioma surgery and cesarean section in the literature.

Year	Author	Age	Previous Pregnancies	Gestational Week	Neurological Symptoms	Localization	Approach	Maternal Outcome	Fetal Outcome	Fetal Weight
1990	Wan et al.[23]	26	G1, P0	32	Vision loss in left eye, left-sided headache, persistent nausea and vomiting	Suprasellar	CS followed by Craniotomy	Hemianopsia in left eye, right eye 20/20 visual acuities. Patient stable.	Alive	N/A
1997	Otton & Walters[24]	26	G2, P1	28	Progressive worsening headache, lethargy, insomnia, anorexia, and vomiting	Frontal Midline	CS followed by Craniotomy	Remarked hemiplegia and sensory loss, emotional liability, memory impairment and reduced problem solving that progressively improve.	APGAR 5–8, Alive	1420 g
1998	Ismail et al.[25]	36	G3, P2	31	Focal seizures affecting the right leg progressing to affecting the right arm and face, and mild paresis in the right upper limb	Left parietal parasagittal	CS followed by a Parietal Parasagittal Craniotomy	Complete Recovery	APGAR 9, Alive	3150 g
2009	Johnson et al.[26]	34	G2, P1	26	Headaches and visual loss, chronic optic nerve atrophy on fundoscopy	Bifrontal Region	Emergency CS for persistent fetal bradycardia during neurosurgical approach	Alive, no recovery from vision loss	APGAR 0-1-1-5, Neonate died at 14th day due to perinatal asphyxia	N/A
2013	Savvina et al.[16]	16	G1, P0	31–32	Headaches, nauseas, vomits, vertigo, right arm weakness, left facial asymmetry, memory loss, walk disturbance, emotional lability, and personality disturbances.	Right convexity Frontal, Temporal, and Parietal Region	CS followed by frontotemporal right craniotomy	Psicoemotional improvement, satisfactory discharge	Alive	1730 g
2014	Kurdoglu et al.[22]	41	G5, P4	39	Progressive visual impairment, confusion, and focal deficits related to raised intracranial pressure	Olfactory Groove	CS followed by Craniotomy	Post-operative diffuse brain infarction, died 3 days after surgery	APGAR 7–9, Alive	3100 g
2023	Javadi et al.[21]	31	G4,Ab1,L1	36	Progressive right hemiparesis and lower limb motor power	Right frontal parasagittal	CS followed by parasagittal craniotomy	Lower limbs motor power recovery, progressive improvement of right side hemiparesis	APGAR 9, Alive	N/A

deterioration, however, there is not one single clinical or surgical indication on the simultaneous performance of these procedures, but a careful analysis of each patient must be done by the multidisciplinary team. With patients whose pregnancies haven't reached the 27th week and need an emergency meningioma resection must be put under rigorous intraoperative monitoring and an effort must be done to preserve the fetuses health during the neurosurgical procedure to prolong the pregnancy as much as possible. The authors consider some of the following punctual specifications and recommendations for the procedure to be necessary: Patient and family consent, fetal intraoperative monitoring, presence of multidisciplinary team inside the operating room, availability of pediatric intensive care unit at the institution where the intervention is performed, decompressive craniectomy due to the hypervolemic state and increased brain edema and performing neurosurgical procedures first to increase the possibility of prolonging pregnancy. If one or some of these recommendations cannot be achieved, ponderation of referring the patient to a center with these capabilities (Such as University Hospitals) must be made, considering that stable transportation of the patient is possible, since these aspects help improve chances of good surgical outcomes both for the mother and the baby.

CRediT authorship contribution statement

Mauricio Guerrero-Ocampo: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft. **Uriel Tagle-Vega:** Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft. **Italo Flecha-Salgueiro:** Conceptualization, Methodology, Project administration, Resources, Supervision, Visualization, Writing – review & editing. **Ana Riquelme:** Project administration, Resources, Supervision, Writing – review & editing. **Dario Diaz:** Project administration, Resources, Supervision, Writing – review & editing. **Fabrizio Frutos:** Conceptualization, Methodology, Project administration, Resources, Supervision, Visualization, Writing – review & editing.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT® and Bard® in order to translate non-english and non-spanish written articles that were included in the systematic review. After using this tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Abbreviations

C-Section: Cesarean section
PRISMA: Preferred Reporting Items For Systematic Reviews and Meta-Analyses
ICP: Intracranial pressure
MeSH: Medical subject headings
GCS: Glasgow Coma Scale
MRI: Magnetic Resonance Imaging
CT Scan: Computed Tomography Scan