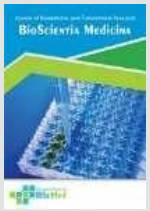
eISSN (Online): 2598-0580



Bioscientia Medicina: Journal of Biomedicine & Translational Research

Journal Homepage: www.bioscmed.com

Delayed-Onset Surgical Site Infection after Sphenoid Wing Meningioma Resection: A Case Report Highlighting Diagnostic and Management Challenges

Sheila Sumargo[1*], Guata Naibaho[1], Roland Sidabutar[1]

[1]Department of Neurosurgery, Faculty of Medicine, Universitas Padjajaran/Dr. Hasan Sadikin General Hospital, Bandung, Indonesia

ARTICLE INFO

Keywords:
Craniotomy
Delayed-onset
Meningioma
Subgaleal abscess
Surgical site infection

***Corresponding author:**
Sheila Sumargo

E-mail address:
sheilasumargo@gmail.com

All authors have reviewed and approved the final version of the manuscript.

https://doi.org/10.37275/bsm.v8i12.1142

A B S T R A C T

Background: Surgical site infections (SSIs) following craniotomy, while uncommon, pose significant risks. Delayed-onset infections can present diagnostic and management challenges. We report a case of delayed-onset SSI after sphenoid wing meningioma resection, emphasizing the importance of vigilance and prompt intervention. **Case presentation**: A 26-year-old male underwent craniotomy for a right sphenoid wing meningioma. He presented 13 days post-operatively with a fluctuant swelling at the surgical site. Imaging revealed a subgaleal and epidural abscess. He underwent craniectomy, debridement, and antibiotic therapy, resulting in complete resolution. **Conclusion:** Delayed-onset SSIs after craniotomy necessitate a high index of suspicion. Early diagnosis and aggressive management, including surgical debridement and appropriate antibiotics, are crucial for optimal outcomes.

1. Introduction

Surgical site infections (SSIs) following intracranial procedures, particularly craniotomies, represent a formidable challenge in neurosurgery, despite significant advancements in aseptic techniques and perioperative care. These infections, though relatively uncommon, can lead to devastating consequences, including meningitis, brain abscess, increased morbidity, prolonged hospitalization, and even mortality. The complexity of intracranial procedures, the proximity to vital neurovascular structures, and the potential for cerebrospinal fluid (CSF) leaks contribute to the inherent risk of SSI in this patient population. The spectrum of SSIs encompasses a range of clinical presentations, from superficial wound infections to deep-seated intracranial abscesses. The timing of onset can also vary, with early-onset infections typically occurring within the first few days postoperatively and delayed-onset infections manifesting days or even weeks later. Delayed-onset SSIs, as exemplified in the case presented here, can pose unique diagnostic and management challenges due to their atypical presentation and potential for misdiagnosis.[1-3]

Sphenoid wing meningiomas, although histologically benign, often necessitate extensive craniotomies due to their anatomical location and potential involvement of critical neurovascular structures, such as the cavernous sinus, internal carotid artery, and optic nerve. The surgical resection

of these tumors can be technically demanding, requiring meticulous dissection and manipulation of delicate tissues. The resulting dead space, coupled with the potential for CSF leaks, creates a fertile environment for bacterial colonization and subsequent infection. The diagnosis of delayed-onset SSI relies on a combination of clinical suspicion, laboratory investigations, and imaging studies. Patients may present with nonspecific symptoms such as headache, fever, or wound discomfort, which can be easily attributed to other postoperative complications. A high index of suspicion is crucial, especially in patients with risk factors for SSI, such as prolonged surgery, extensive tissue manipulation, the use of implants, and CSF leaks.[4-6] Imaging modalities, such as contrast-enhanced computed tomography (CT) or magnetic resonance imaging (MRI), play a pivotal role in the diagnosis of SSI. These imaging studies can identify collections of fluid or inflammatory changes at the surgical site, aiding in the differentiation between SSI and other postoperative complications. The management of delayed-onset SSI necessitates a multidisciplinary approach, encompassing surgical debridement, appropriate antibiotic therapy, and supportive care. Surgical debridement aims to remove infected tissues and establish adequate drainage, thereby facilitating wound healing and preventing further spread of infection. The choice of antibiotic therapy should be guided by culture and sensitivity results, ensuring adequate coverage against the offending pathogens.[7,8]

The prevention of SSI after craniotomy involves a multifaceted strategy, encompassing preoperative optimization of patient factors, meticulous surgical technique, and appropriate antibiotic prophylaxis. Preoperative measures include optimizing glycemic control, smoking cessation, and treating any pre-existing infections. Intraoperative strategies include minimizing tissue trauma, meticulous hemostasis, and judicious use of implants. Postoperative care involves careful wound management and early recognition of any signs of infection.[9,10] In this case report, we present a case of delayed-onset SSI following sphenoid wing meningioma resection. The patient developed a subgaleal and epidural abscess 13 days after surgery, highlighting the importance of maintaining a high index of suspicion for SSI even in the subacute postoperative period. This case underscores the need for prompt diagnosis and aggressive management to minimize complications and optimize patient outcomes.

2. Case Presentation

A 26-year-old male presented to our neurosurgical clinic with a chief complaint of progressively worsening blurred vision in both eyes, accompanied by intermittent headaches that had persisted for approximately 2.5 years. The visual impairment was not associated with diplopia (double vision) or any discernible visual field defects. Notably, the patient denied any significant past medical or surgical history, emphasizing the insidious onset and gradual progression of his symptoms. Upon neurological examination, the patient's vital signs were within normal limits, and there were no overt neurological deficits. Motor and sensory functions were intact, and no pathological reflexes were elicited. However, a comprehensive ophthalmological assessment revealed bilateral blurred vision, prompting further investigation into the underlying etiology. A contrast-enhanced computed tomography (CT) scan of the head was performed, which unveiled a significant intracranial pathology. The scan demonstrated a hyperdense, extra-axial lesion situated at the right sphenoid wing. This lesion exhibited characteristic features of a meningioma, including its well-defined borders, homogenous enhancement, and associated hyperostosis of the adjacent bone. The mass effect exerted by the tumor was substantial, resulting in compression of the surrounding brain structures, including the sulci, gyri, Sylvian fissure, ventricles, and cisterns in the right frontotemporoparietal region. Furthermore, there was evidence of perifocal edema, indicative of brain tissue inflammation and swelling in response to the tumor. The midline shift of greater than 5 mm to the left underscored the significant mass

effect and potential for neurological compromise. Based on the clinical presentation and imaging findings, a diagnosis of a supratentorial space-occupying lesion (SOL) in the right frontotemporal region was established, with a strong suspicion of a lateral sphenoid wing meningioma. The patient was subsequently scheduled for surgical intervention to address the tumor and alleviate its associated mass effect.

The patient underwent a right frontotemporal craniotomy for tumor resection. The surgical procedure was meticulously executed, with careful navigation through the complex anatomical landscape of the sphenoid wing region. The tumor was successfully resected in its entirety, and meticulous hemostasis was achieved to minimize the risk of postoperative complications. Intraoperative monitoring and neurophysiological assessments were employed to safeguard critical neurovascular structures and ensure the preservation of neurological function. Postoperative imaging confirmed the complete removal of the tumor, and the patient's immediate postoperative course was uneventful. He demonstrated no new neurological deficits and exhibited a satisfactory recovery. On the third postoperative day, the patient was discharged home with appropriate pain management and instructions for wound care. Thirteen days after the craniotomy, the patient presented to the emergency department with a new and concerning symptom: a progressively enlarging, painful swelling at the surgical site on his right forehead. The swelling was associated with localized erythema (redness) and tenderness, raising suspicion for a possible postoperative complication. Upon physical examination, the surgical scar on the right frontotemporoparietal region appeared intact, with no evidence of wound dehiscence or CSF leakage. However, the swelling exhibited fluctuance, suggesting the presence of an underlying fluid collection. Neurological examination remained unremarkable, indicating no new or worsening neurological deficits.

To further evaluate the nature of the swelling, a contrast-enhanced CT scan of the head was performed. The scan revealed a hypodense (darker) lesion located in the extracalvarial space, specifically in the subgaleal region at the right frontotemporoparietal area. This finding, in conjunction with the clinical presentation, strongly suggested the presence of a subgaleal abscess, a collection of pus beneath the scalp. Furthermore, the CT scan also demonstrated a hypodense collection in the epidural space, the potential space between the dura mater (the outermost layer of the meninges) and the skull. This finding indicated the presence of an epidural abscess, a serious complication that can lead to neurological compromise if left untreated. Based on the clinical and radiological findings, a definitive diagnosis of delayed-onset surgical site infection (SSI) was established. The infection manifested as a subgaleal abscess and an epidural abscess, both located at the right frontotemporoparietal region, the site of the previous craniotomy. The underlying cause of the infection was attributed to the recent tumor removal procedure. The histopathological analysis of the resected tumor confirmed the diagnosis of a meningothelial meningioma, a World Health Organization (WHO) Grade I tumor. The patient was promptly taken back to the operating room for urgent surgical intervention. A craniectomy was performed to access the infected areas, and meticulous debridement of the subgaleal and epidural spaces was undertaken. During the procedure, approximately 40 cc of purulent material was evacuated from the subgaleal space, and the epidural space was thoroughly irrigated and debrided to eliminate any residual infection. The dura mater, fortunately, remained intact, obviating the need for further intervention. However, due to the extensive nature of the infection, the bone flap was not replaced, leaving a substantial bone defect measuring 13x10 cm.

Following the surgical debridement, cultures were obtained from the purulent material, which subsequently grew *Staphylococcus aureus*, a common pathogen in SSIs. The bacterium was sensitive to

methicillin, guiding the selection of appropriate antibiotic therapy. The patient was initiated on intravenous vancomycin and ceftriaxone, broad-spectrum antibiotics that provide effective coverage against *Staphylococcus aureus*. Throughout the postoperative course, the patient remained afebrile and exhibited no neurological deterioration. The wound healed gradually by secondary intention, and the antibiotic regimen was continued for a total of six weeks to ensure complete eradication of the infection. Regular follow-up visits were scheduled to monitor the wound healing process and assess for any signs of recurrence.

The patient's recovery was uneventful, and he experienced a complete resolution of the SSI. Subsequent imaging studies confirmed the absence of any residual infection or intracranial complications. The bone defect was managed conservatively, and the patient was advised on the possibility of future cranioplasty for cosmetic and functional purposes. Long-term follow-up was instituted to monitor for any late sequelae of the infection or tumor recurrence. The patient remained asymptomatic and exhibited no neurological deficits. The successful management of this delayed-onset SSI underscores the importance of early diagnosis and aggressive intervention in mitigating the potential complications of postoperative infections in neurosurgical patients.

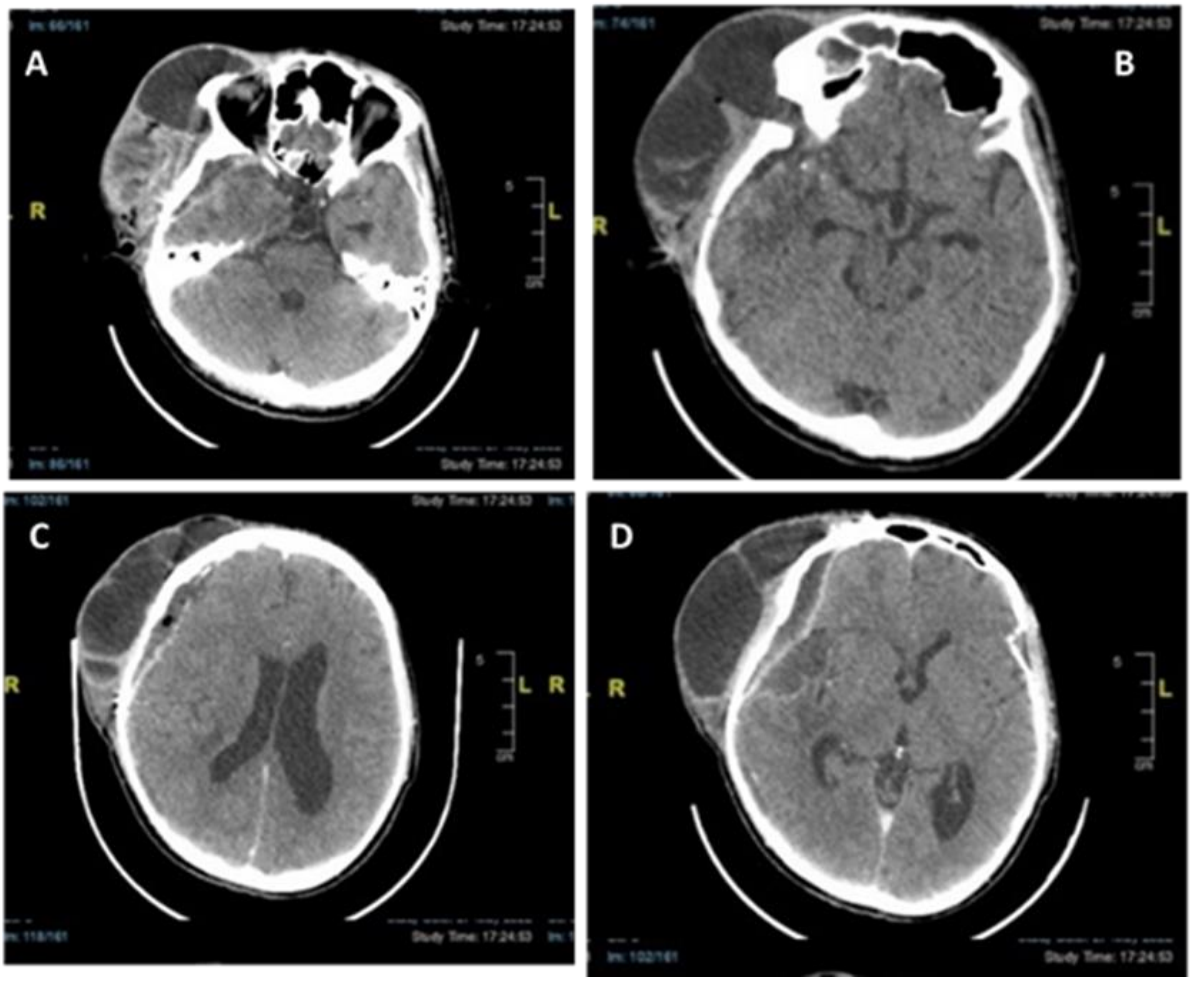


Figure 1. Post-operative contrast head CT scan showing hypodense lesion extracalvaria at right frontotemporoparietal.

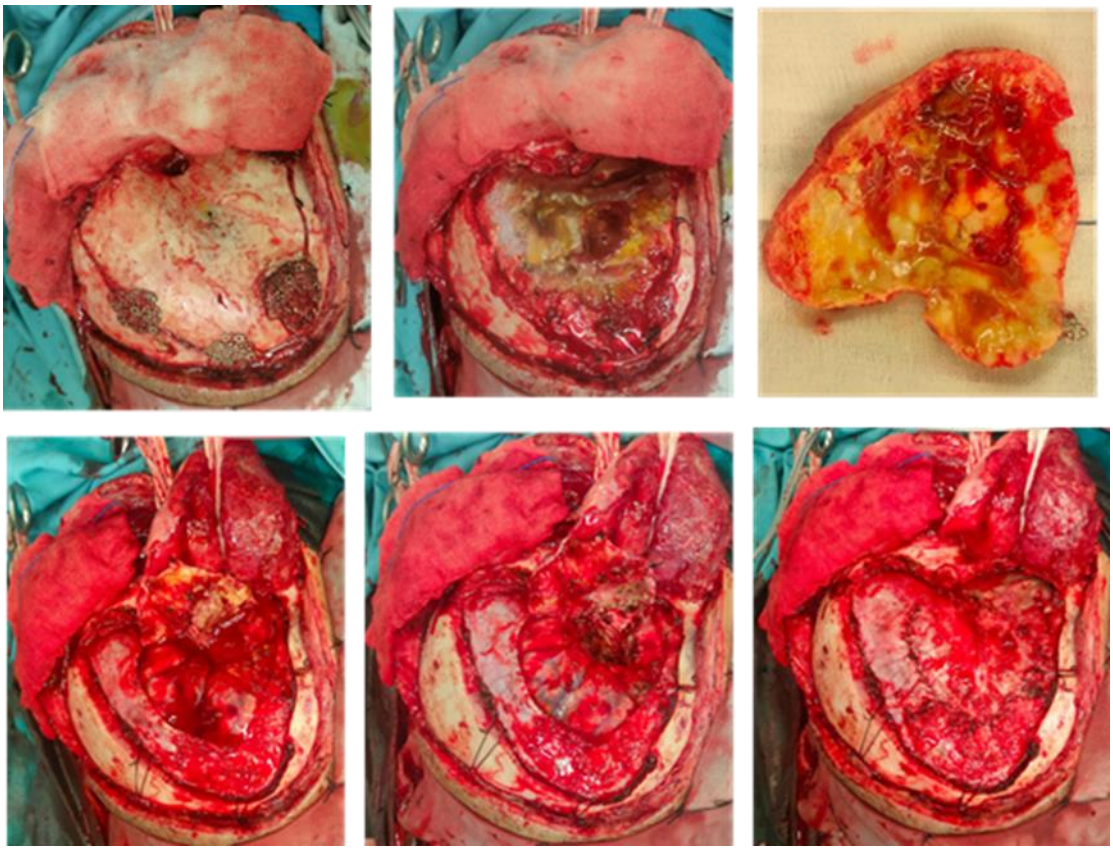


Figure 2. Intraoperative findings.

3. Discussion

Delayed-onset surgical site infections (SSIs) represent a formidable diagnostic challenge in the realm of neurosurgery. These infections, typically manifesting more than a week after the surgical procedure, often present with a constellation of nonspecific symptoms that can easily be misconstrued as normal postoperative sequelae or attributed to other complications. This diagnostic ambiguity can lead to delays in recognition and treatment, potentially resulting in devastating consequences for the patient. The postoperative period following craniotomy is inherently fraught with a myriad of physiological changes and potential complications. Pain, swelling, and discomfort at the surgical site are commonplace, often attributed to the invasive nature of the procedure itself. Similarly, headaches, fatigue, and even low-grade fever can be considered par for the course in the initial days and weeks following surgery. This backdrop of expected postoperative symptoms can inadvertently mask the subtle harbingers of a brewing infection. The patient in our case, for instance, presented with a progressively enlarging, painful swelling at the surgical site 13 days after the procedure. While this could certainly raise suspicion for an SSI, it is also plausible that such a presentation could be attributed to a hematoma, seroma, or even an aseptic inflammatory reaction. Further complicating the diagnostic picture is the nonspecific nature of the symptoms associated with delayed-onset SSIs. Headache, a common complaint in the postoperative period, can also be a manifestation of an intracranial infection. Similarly, wound discomfort, often dismissed as a natural consequence of the healing process, can also signal an underlying infection. The patient in our case also complained of wound discomfort, a symptom that could easily be attributed to the normal postoperative course. This nonspecific symptom, in the absence of other overt signs of infection, could potentially lead to a delay in diagnosis and appropriate intervention. Given the potential for delayed-onset SSIs to masquerade as

other postoperative complications, maintaining a high index of suspicion is paramount. Any new or worsening symptoms, particularly those localized to the surgical site, should prompt a thorough evaluation to rule out the possibility of an infection. This vigilance is particularly crucial in patients with risk factors for SSI, such as those undergoing extensive craniotomies, those with prolonged surgical durations, or those with comorbidities that compromise their immune system. In the context of sphenoid wing meningioma resection, the extensive nature of the surgery and the potential for CSF leaks further elevate the risk of SSI, necessitating heightened awareness and proactive monitoring for any signs of infection. While clinical suspicion is the cornerstone of diagnosing delayed-onset SSIs, it is imperative to corroborate these suspicions with objective diagnostic modalities. Imaging studies, such as contrast-enhanced CT or MRI, play a pivotal role in this regard. These modalities can identify collections of fluid or inflammatory changes at the surgical site, aiding in the differentiation between SSI and other postoperative complications. In our case, the CT scan revealed a hypodense collection in the subgaleal and epidural spaces, confirming the presence of an abscess and solidifying the diagnosis of SSI. This underscores the importance of utilizing appropriate imaging studies to confirm or refute clinical suspicions and guide subsequent management decisions. The consequences of delayed diagnosis and treatment of SSIs can be dire. Untreated infections can progress rapidly, leading to meningitis, brain abscess, and other life-threatening complications. Therefore, timely intervention is of the essence. Once the diagnosis of SSI is established, prompt and aggressive management is warranted. This typically involves surgical debridement to remove infected tissues and establish adequate drainage, coupled with appropriate antibiotic therapy to eradicate the offending pathogens. Sphenoid wing meningiomas, despite their classification as benign tumors, present a unique set of challenges that significantly elevate the risk of surgical site infections (SSIs) following their resection. These challenges stem primarily from their anatomical location and the intricate surgical procedures required for their removal. The sphenoid wing, forming a crucial part of the skull base, houses a complex network of vital neurovascular structures, including the cavernous sinus, internal carotid artery, optic nerve, and several cranial nerves. Meningiomas arising from this region often infiltrate or encase these structures, necessitating meticulous dissection and manipulation to achieve complete tumor resection without compromising neurological function. The surgical approach to sphenoid wing meningiomas typically involves an extensive craniotomy, often extending across the frontotemporal region. This extensive bone removal creates a large surgical field, increasing the potential for contamination and bacterial colonization. Moreover, the intricate dissection required to navigate the complex anatomy of the skull base can lead to prolonged surgical durations, further amplifying the risk of SSI. The proximity of the surgical site to the paranasal sinuses and the potential for inadvertent dural tears during tumor resection can also contribute to the elevated risk of SSI. The paranasal sinuses harbor a diverse microbial flora, and any communication between the surgical field and the sinuses can facilitate bacterial translocation and subsequent infection. Similarly, CSF leaks, which can occur due to dural tears, provide a direct pathway for bacteria to invade the intracranial space, potentially leading to devastating complications such as meningitis or brain abscess. The resection of a sphenoid wing meningioma often results in a significant dead space, a cavity created by the removal of the tumor. This dead space, if not adequately obliterated, can accumulate blood and serum, providing a fertile breeding ground for bacteria. The presence of blood and serum, coupled with the reduced blood flow and oxygen tension in the dead space, creates an ideal environment for bacterial proliferation and the establishment of an infection. Various techniques can be employed to minimize dead space following tumor resection, including the use of dural substitutes, fat grafts, or muscle flaps. However,

even with meticulous surgical technique, the potential for residual dead space remains, particularly in cases of large or extensive tumors. Cerebrospinal fluid (CSF) leaks, although not always present, can significantly increase the risk of SSI following sphenoid wing meningioma resection. CSF provides a nutrient-rich medium for bacterial growth, and any leakage into the surgical site can facilitate rapid bacterial colonization and the establishment of an infection. The identification and repair of CSF leaks are crucial for minimizing the risk of SSI. Various techniques can be employed to achieve watertight dural closure, including the use of sutures, fibrin glue, or dural substitutes. In cases of persistent or recurrent CSF leaks, lumbar drainage or even reoperation may be necessary to prevent infection. The case presented in this report serves as a poignant reminder of the challenges associated with delayed-onset SSIs following sphenoid wing meningioma resection. The patient developed a subgaleal and epidural abscess 13 days after surgery, highlighting the insidious nature of these infections and the potential for delayed presentation. The extensive nature of the craniotomy, coupled with the potential for CSF leakage, likely contributed to the development of the SSI in this case. The presence of both a subgaleal and epidural abscess underscores the vulnerability of the surgical site to infection and the potential for rapid spread to adjacent structures.[11,12]

The microbial landscape of surgical site infections (SSIs) following craniotomy is a complex and dynamic entity, shaped by a multitude of factors, including the patient's endogenous flora, the surgical environment, and the specific procedures performed. Understanding this microbial milieu is crucial for selecting appropriate empiric antibiotic therapy and tailoring subsequent treatment based on culture and sensitivity results. The skin, harboring a diverse array of microorganisms, serves as the primary source of contamination in most post-craniotomy SSIs. *Staphylococcus aureus*, a ubiquitous gram-positive bacterium commonly found on the skin and mucous membranes, reigns supreme as the most frequently isolated pathogen in these infections. Its ability to form biofilms, evade host immune responses, and develop antibiotic resistance makes it a particularly formidable adversary. Coagulase-negative staphylococci (CoNS), another group of gram-positive bacteria residing on the skin, also contribute significantly to the burden of post-craniotomy SSIs. While generally less virulent than *S. aureus*, CoNS can cause significant morbidity, particularly in immunocompromised patients or those with implanted devices. Gram-negative bacilli, including *Pseudomonas aeruginosa* and Enterobacteriaceae, represent another potential source of infection. These organisms, often found in the gut and environment, can contaminate the surgical site through various routes, including hematogenous spread or direct inoculation. Their propensity for developing multidrug resistance poses a significant therapeutic challenge. In the face of a suspected SSI, prompt initiation of empiric antibiotic therapy is crucial to prevent further spread of infection and mitigate potential complications. The choice of empiric antibiotics should be guided by the most likely pathogens, local antibiogram patterns, and the patient's clinical status. Broad-spectrum coverage against gram-positive and gram-negative organisms is typically warranted, given the polymicrobial nature of many SSIs. Vancomycin, a glycopeptide antibiotic with excellent activity against gram-positive bacteria, including methicillin-resistant *S. aureus* (MRSA), is often a cornerstone of empiric therapy. Its bactericidal action and ability to penetrate the blood-brain barrier make it particularly valuable in the context of intracranial infections. Ceftriaxone, a third-generation cephalosporin with broad-spectrum activity against gram-negative bacteria, is frequently combined with vancomycin to provide comprehensive coverage. Its favorable pharmacokinetic profile and ability to penetrate the central nervous system further enhance its utility in the treatment of post-craniotomy SSIs. While empiric antibiotic therapy is essential for initial management, it is imperative to tailor subsequent treatment based on culture and sensitivity results. This approach ensures that the

most appropriate antibiotics are used, minimizing the risk of adverse events and promoting optimal outcomes. In the case presented, the culture from the abscess grew methicillin-sensitive *Staphylococcus aureus* (MSSA), obviating the need for continued vancomycin therapy. The patient was transitioned to a narrower-spectrum antibiotic, such as nafcillin or oxacillin, to complete the course of treatment. The optimal duration of antibiotic therapy for post-craniotomy SSIs remains a subject of debate. However, most experts recommend a prolonged course, typically ranging from 4 to 6 weeks, to ensure complete eradication of the infection and minimize the risk of recurrence. In this case, the patient received a six-week course of intravenous antibiotics, a duration deemed sufficient to address the extensive nature of the infection and the presence of an epidural abscess. While antibiotics are indispensable in the management of SSIs, their judicious use is paramount to prevent the emergence of antibiotic resistance. Antimicrobial stewardship programs, which promote the appropriate selection, dosage, and duration of antibiotic therapy, play a crucial role in preserving the efficacy of these life-saving drugs. Obtaining cultures before initiating antibiotic therapy whenever possible. Selecting empiric antibiotics based on the most likely pathogens and local antibiogram patterns. Tailoring therapy based on culture and sensitivity results. Using the shortest effective duration of antibiotic therapy. Monitoring for adverse events and adjusting therapy as needed. While antibiotics are essential for eradicating the infection, surgical debridement remains the cornerstone of managing SSIs, particularly those involving abscess formation. This procedure involves the removal of all infected and necrotic tissues, establishing adequate drainage, and facilitating wound healing. In the case presented, the patient underwent urgent craniectomy and meticulous debridement of the subgaleal and epidural spaces. This aggressive surgical approach, coupled with appropriate antibiotic therapy, resulted in complete resolution of the infection and prevented further complications.[13,14]

The cornerstone of managing surgical site infections (SSIs), especially those that have progressed to abscess formation, lies in the meticulous execution of surgical debridement. This pivotal procedure serves a tripartite purpose: the removal of all infected and necrotic tissues, the establishment of effective drainage pathways, and the creation of an optimal environment for wound healing. In the context of the presented case, the patient's condition necessitated an urgent craniectomy, a procedure involving the removal of a portion of the skull, to gain access to the infected subgaleal and epidural spaces. This was followed by a thorough and meticulous debridement of these spaces, ensuring the complete removal of purulent material and devitalized tissue. Surgical debridement acts as a critical first step in interrupting the infectious process. By removing the nidus of infection, it disrupts the bacterial biofilm, reduces the bacterial load, and enhances the penetration of antibiotics to the affected tissues. Furthermore, debridement helps to relieve pressure and inflammation, thereby promoting blood flow and oxygen delivery to the wound bed, which are essential for tissue repair and regeneration. The meticulous nature of debridement is particularly crucial in the context of intracranial SSIs. The proximity of the infection to vital neurovascular structures necessitates a delicate balance between thoroughness and preservation of function. The surgeon must navigate this intricate landscape with precision, ensuring complete removal of infected tissue while minimizing collateral damage. In the presented case, the debridement of the subgaleal and epidural spaces was performed with utmost care, resulting in the successful eradication of the infection without any neurological sequelae. The intact dura mater, a testament to the surgeon's skill and precision, obviated the need for further intracranial intervention. The decision to leave the bone flap out following craniectomy for SSI is a complex one, fraught with potential benefits and risks. On the one hand, bone flap removal allows for continuous monitoring of the infection and facilitates further debridement if necessary. It also prevents the bone flap from acting

as a nidus for persistent or recurrent infection. On the other hand, the absence of the bone flap carries the risk of cosmetic deformity and potential complications, such as seizures, brain injury, or herniation. The patient's psychological well-being and social reintegration can also be significantly impacted by the cosmetic defect. In the presented case, the extensive nature of the infection and the desire to ensure complete eradication prompted the decision to leave the bone flap out. The patient was counseled on the potential risks and benefits of this approach and the possibility of future cranioplasty for cosmetic and functional rehabilitation. The wound, following debridement and bone flap removal, was allowed to heal by secondary intention. This process, although slower than primary closure, is often preferred in cases of extensive infection or significant tissue loss. It involves the gradual filling of the defect with granulation tissue, followed by epithelialization and wound contraction. Secondary intention healing offers several advantages in the context of SSI management. It allows for continuous drainage of any residual infection, minimizes the risk of wound breakdown and recurrence, and promotes the formation of a durable scar. However, it is important to acknowledge that this approach can lead to prolonged healing times and potential cosmetic concerns. In the presented case, the wound healed satisfactorily by secondary intention, with no evidence of recurrence or complications. The patient was closely monitored throughout the healing process, and appropriate wound care measures were instituted to optimize the outcome. The successful management of SSIs, particularly those following complex neurosurgical procedures, necessitates a multidisciplinary approach. The surgeon, infectious disease specialist, and nursing staff must work in concert to ensure optimal patient outcomes. The surgeon's expertise lies in the meticulous execution of debridement and the judicious decision-making regarding bone flap replacement and wound closure. The infectious disease specialist plays a crucial role in selecting appropriate antibiotic therapy, monitoring for adverse events, and ensuring complete eradication of the infection. The nursing staff provides invaluable support in wound care, pain management, and patient education. In the presented case, the collaborative efforts of the multidisciplinary team culminated in the successful resolution of the SSI and the patient's complete recovery. This case serves as a testament to the importance of teamwork and coordinated care in managing complex postoperative complications.[15,16]

The prevention of surgical site infections (SSIs) following craniotomy represents a multifaceted endeavor, demanding a strategic and comprehensive approach that encompasses preoperative optimization, meticulous surgical technique, judicious use of prophylactic antibiotics, and vigilant postoperative care. This multi-pronged strategy aims to erect a formidable fortress against infection, safeguarding patients from the potentially devastating consequences of SSIs. The preoperative phase presents a crucial window of opportunity to optimize patient factors and minimize the risk of SSI. This involves a thorough assessment of the patient's medical history, identification of potential risk factors, and implementation of targeted interventions to mitigate these risks. In patients with diabetes, achieving optimal glycemic control is paramount. Hyperglycemia has been shown to impair wound healing and immune function, thereby increasing the susceptibility to infection. Careful monitoring of blood glucose levels and appropriate insulin therapy are essential in this population. Smoking is a well-established risk factor for SSI, as it impairs tissue oxygenation and wound healing. Encouraging smoking cessation, even for a short period before surgery, can significantly reduce the risk of infection. Nicotine replacement therapy or other smoking cessation aids may be offered to facilitate this process. Any pre-existing infections, whether local or systemic, should be identified and treated before proceeding with elective craniotomy. This includes infections of the skin, respiratory tract, or urinary tract, as these can serve as reservoirs for bacteria that can potentially contaminate the surgical site. The nasal passages

harbor *Staphylococcus aureus*, a common pathogen in SSIs. Nasal decolonization with topical antibiotics, such as mupirocin, can reduce the risk of SSI, particularly in patients undergoing procedures involving implantation of foreign material. Adequate nutrition is essential for wound healing and immune function. Malnourished patients are at increased risk of SSI, and efforts should be made to optimize their nutritional status before surgery. This may involve dietary modifications, nutritional supplements, or even enteral or parenteral nutrition in severe cases. The psychological well-being of the patient can also influence the risk of SSI. Anxiety and stress have been shown to impair immune function, potentially increasing susceptibility to infection. Providing adequate psychological support and addressing any concerns or anxieties can help to optimize the patient's overall health and resilience. The intraoperative phase demands unwavering adherence to the principles of aseptic technique. Every step of the surgical procedure, from skin preparation to wound closure, must be executed with meticulous precision to minimize the risk of contamination and bacterial colonization. The surgical site should be thoroughly cleansed with an antiseptic solution, such as chlorhexidine gluconate, to reduce the bacterial load on the skin. Hair removal, if necessary, should be performed immediately before surgery using clippers or depilatory creams, as shaving can increase the risk of microabrasions and subsequent infection. Sterile drapes should be used to create a barrier between the surgical site and the surrounding environment, further minimizing the risk of contamination. Gentle tissue handling is essential to minimize trauma and preserve blood flow, both of which are crucial for wound healing and infection resistance. Excessive cauterization should be avoided, as it can lead to tissue necrosis and create a fertile ground for bacterial growth. Meticulous hemostasis is vital to prevent the accumulation of blood and serum in the surgical site, which can serve as a culture medium for bacteria. Various techniques can be employed to achieve hemostasis, including electrocautery, sutures, and topical hemostatic agents. While implants, such as dural substitutes or bone grafts, are often necessary in craniotomy procedures, their use should be judicious. Implants can act as foreign bodies, potentially triggering an inflammatory response and increasing the risk of infection. The choice of implant material and its proper handling are crucial for minimizing these risks. The wound should be closed in layers, ensuring adequate approximation of tissues and minimizing dead space. The use of drains may be considered in certain cases to facilitate the removal of fluid and reduce the risk of seroma formation. The use of prophylactic antibiotics is a cornerstone of SSI prevention in neurosurgery. These antibiotics, administered shortly before the incision, aim to achieve adequate tissue concentrations at the surgical site during the procedure, thereby reducing the risk of bacterial colonization and subsequent infection. The choice of antibiotic should be based on the anticipated pathogens, local antibiogram patterns, and the patient's allergy history. Cefazolin, a first-generation cephalosporin with excellent activity against gram-positive bacteria, is often the preferred agent for craniotomy procedures. In cases where there is a concern for MRSA or gram-negative coverage, vancomycin or a broader-spectrum antibiotic may be warranted. The timing of antibiotic administration is also crucial. Ideally, the antibiotic should be administered within 60 minutes before the incision to ensure adequate tissue concentrations during the critical period of bacterial contamination. The postoperative phase demands continued vigilance and proactive monitoring for any signs of infection. Patients should be educated on proper wound care techniques and instructed to report any new or worsening symptoms promptly. The surgical wound should be kept clean and dry, and dressings should be changed regularly using aseptic technique. Any signs of infection, such as redness, swelling, warmth, or purulent drainage, should be reported to the healthcare team immediately. Adequate pain management is essential for patient comfort and mobilization, which can help to prevent complications

such as pneumonia or deep vein thrombosis. Early recognition of SSI is crucial for prompt intervention and optimal outcomes. Any new or worsening symptoms, such as fever, headache, wound discomfort, or neurological deficits, should raise suspicion for infection and prompt further evaluation. If SSI is suspected, a thorough diagnostic workup should be initiated, including blood cultures, wound cultures, and imaging studies. This will help to identify the offending pathogen and guide subsequent management decisions. Once the diagnosis of SSI is established, prompt and aggressive management is warranted. This typically involves surgical debridement, appropriate antibiotic therapy, and supportive care.[17,18]

The case presented in this report serves as a poignant reminder of the potential for delayed-onset surgical site infections (SSIs) following craniotomy, even in seemingly uncomplicated cases. It underscores the critical importance of adopting a proactive and vigilant approach to patient care, encompassing the entire perioperative period, to mitigate the risk of SSIs and optimize patient outcomes. The following implications for clinical practice emerge from this case and the broader literature on SSIs in neurosurgery: The insidious nature of delayed-onset SSIs, often presenting with nonspecific symptoms that can be easily attributed to other postoperative complications, necessitates a heightened level of clinical suspicion. Any new or worsening symptoms, particularly those localized to the surgical site, should prompt a thorough evaluation to rule out the possibility of an infection. This vigilance should extend beyond the immediate postoperative period, as delayed-onset SSIs can manifest days or even weeks after surgery. The patient in this case presented 13 days postoperatively with a progressively enlarging, painful swelling at the surgical site. While this presentation could raise suspicion for an SSI, it is also plausible that such a presentation could be attributed to a hematoma, seroma, or even an aseptic inflammatory reaction. The nonspecific nature of the patient's symptoms, including headache and wound discomfort, further complicated the diagnostic process. This case emphasizes the critical importance of not dismissing any new or unusual symptoms in the postoperative period. A comprehensive assessment, including a detailed history, physical examination, and appropriate diagnostic tests, should be undertaken to rule out the possibility of an SSI. This proactive approach can lead to early diagnosis and timely intervention, thereby preventing the progression of the infection and its associated complications. Early diagnosis of SSI is paramount, as it allows for prompt and aggressive management, which is crucial for optimizing patient outcomes. Once the diagnosis is established, a multidisciplinary approach, encompassing surgical debridement, appropriate antibiotic therapy, and supportive care, should be instituted without delay. Surgical debridement, the cornerstone of SSI management, aims to remove all infected and necrotic tissues, establish adequate drainage, and create an optimal environment for wound healing. In the case presented, the patient underwent urgent craniectomy and meticulous debridement of the subgaleal and epidural spaces, leading to successful eradication of the infection. The choice of antibiotic therapy should be guided by culture and sensitivity results, ensuring adequate coverage against the offending pathogens. In this case, the patient was initially treated with broad-spectrum antibiotics, which were subsequently tailored based on culture results. The duration of antibiotic therapy should be sufficient to ensure complete eradication of the infection and minimize the risk of recurrence. Supportive care measures, such as pain management, wound care, and nutritional support, are also essential components of SSI management. These measures help to optimize the patient's overall health and facilitate the healing process. The prevention of SSIs is a complex endeavor that requires a multifaceted approach, encompassing preoperative optimization, meticulous surgical technique, and appropriate antibiotic prophylaxis. Preoperative optimization aims to identify and mitigate potential risk factors for SSI. This includes optimizing

glycemic control in patients with diabetes, encouraging smoking cessation, treating any pre-existing infections, and addressing nutritional deficiencies. Meticulous surgical technique is paramount in minimizing the risk of contamination and bacterial colonization. This involves strict adherence to aseptic principles, gentle tissue handling, meticulous hemostasis, and judicious use of implants. Prophylactic antibiotics, administered shortly before the incision, provide an additional layer of protection against infection. The choice of antibiotic should be based on the anticipated pathogens and local antibiogram patterns. Patient education and follow-up play a crucial role in SSI prevention and management. Patients should be educated on proper wound care techniques and instructed to report any new or worsening symptoms promptly. Regular follow-up visits are essential to monitor the healing process, assess for any signs of recurrence, and address any concerns or anxieties that the patient may have. Empowering patients to take an active role in their care can significantly improve outcomes and reduce the burden of SSI. By providing them with the knowledge and tools to recognize and report any potential complications, we can ensure timely intervention and prevent the progression of infection.[19,20]

4. Conclusion

This case report underscores the critical importance of maintaining a high index of suspicion for delayed-onset surgical site infections (SSIs) following craniotomy, even in seemingly uncomplicated cases. The insidious nature of these infections, coupled with their potential for devastating consequences, necessitates a proactive and vigilant approach to patient care. Early diagnosis, prompt surgical intervention, and appropriate antibiotic therapy are paramount in mitigating the morbidity and mortality associated with SSIs. Furthermore, a multifaceted prevention strategy, encompassing preoperative optimization, meticulous surgical technique, and judicious use of prophylactic antibiotics, is essential for minimizing the risk of SSI and ensuring optimal patient outcomes in neurosurgery.

5. References

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