Postoperative *Mycoplasma hominis* infections after neurosurgical intervention

A review

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Object. *Mycoplasma hominis* is a rare cause of infection after neurosurgical procedures. The *Mycoplasma* genus contains the smallest bacteria discovered to date. *Mycoplasma* are atypical bacteria that lack a cell wall, a feature that complicates both diagnosis and treatment. The Gram stain and some types of culture media fail to identify these organisms, and typical broad-spectrum antibiotic regimens are ineffective because they act on cell wall metabolism. *Mycoplasma hominis* commonly colonizes the genitourinary tract in a nonvirulent manner, but it has caused postoperative, postpartum, and posttraumatic infections in various organ systems.

The authors present the case of a 17-year-old male with a postoperative intramedullary spinal cord abscess due to *M. hominis* and report the results of a literature review of *M. hominis* infections after neurosurgical procedures. Attention is given to time to diagnosis, risk factors for infection, ineffective antibiotic regimens, and final effective antibiotic regimens to provide pertinent information for the practicing neurosurgeon to diagnose and treat this rare occurrence.

Methods. A PubMed search was performed to identify reports of *M. hominis* infections after neurosurgical procedures.

Results. Eleven cases of postneurosurgical *M. hominis* infection were found. No other cases of intramedullary spinal cord abscess were found. Initial antibiotic coverage was inadequate in all cases, and diagnosis was delayed in all cases. Multiple surgical interventions were often needed. Once appropriate antibiotics were started, patients typically experienced rapid resolution of their neurological symptoms. In 27% of cases, a suspicious genitourinary source other than urinary catheterization was identified.

Conclusions. Postoperative *M. hominis* infections are rarely seen after neurosurgical procedures. They are typically responsive to appropriate antibiotic therapy. *Mycoplasma* infection may cause prolonged hospitalization and multiple returns to the operating room due to delay in diagnosis. Early clinical suspicion with appropriate antibiotic coverage could help prevent these significant complications.

Key Words • *Mycoplasma hominis* • intramedullary • abscess • spine • brain • infection

*Mycoplasma hominis* is a rare complication of neurosurgical procedures. The organism lacks a cell wall and instead has a 3-layer sterol membrane, so it does not appear on Gram stain.13 To culture *M. hominis*, specialized media containing animal serum are needed.14 Polymerase chain reaction (PCR) may be the most sensitive method for diagnosis, but it is not routinely performed.13 For these reasons, diagnosis is often delayed. Because it is an atypical bacterium, *M. hominis* does not respond to common empirical antibiotics, which act on cell wall metabolism.13 This leads to initially inadequate antibiotic coverage of postoperative infections.

*Mycoplasma hominis* is known to asymptptomatically colonize the genitourinary system, where it acts as a parasite living on the nutrients available. It is typically unable to infiltrate beyond the submucosa of the genitourinary tract. When acting in a virulent manner, it has been most commonly implicated in cases of cervicitis, urinary tract infections (UTIs), pelvic inflammatory disease, postpartum infections, and postabortal fever.13 However, small numbers of infections have been reported in multiple sites outside the genitourinary system.12,15,17,20 Case reports have shown that *M. hominis* can cause spontaneous meningitis or postoperative neurosurgical infections.

There are several other related microorganisms that lack a cell wall and therefore cause the same diagnostic and therapeutic difficulties as *M. hominis. Mycoplasma pneumoniae* colonizes the respiratory tract and is well known for its role in “walking pneumonia.” *Mycoplasma genitalium* colonizes the genitourinary tract and has been associated with pelvic inflammatory disease. *Ureaplasma*
Postneurosurgical *M. hominis* infections

*ma parvum* and *U. urealyticum* also colonize the genitourinary tract and are known to cause urethritis. Like *M. hominis*, these organisms have more rarely been implicated in neonatal and postoperative wound infections, and remain in the differential diagnosis for persistent infections when no organism has been identified by culture.

We present the case report of a 17-year-old patient who developed a postoperative intramedullary spinal cord abscess from *M. hominis* after 360° fixation and fusion following cervical fracture and dislocation sustained in a motor vehicle collision (MVC). To the best of our knowledge, this is the first intramedullary *M. hominis* infection reported in the literature, as well as the first review of postoperative infections from *M. hominis* in both the spine and brain.

**Illustrative Case Report**

**History.** A 17-year-old male presented with multiple trauma after an MVC that occurred while he was driving under the influence of alcohol. He sustained multiple spinal injuries, including C6–7 fracture-dislocation with bilateral jumped facets, 9 mm of anterolisthesis, and 75% spinal canal narrowing (Fig. 1). He also sustained a left C-1 lateral mass fracture, left C-3 facet fracture, and left C-5 facet fracture with associated left vertebral artery dissection. Other injuries included scalp avulsion, right orbital floor fracture, left mandible fracture, and right hand degloving injury.

**Examination.** He was intubated in the field for airway protection. On examination, he was able to flex his arms to noxious stimulation bilaterally, but he had no signs of distal arm or leg function. He was started on the methylprednisolone protocol for acute spinal cord injury (SCI). Urinalysis after Foley catheter placement showed blood but no bacteria.

**Operation.** He was taken to the operating room for C-6 corpectomy with C5–7 anterior fixation and fusion.

Postoperative MRI studies showed persistent cord compression, so he was returned to the operating room immediately for posterior decompression and fusion from C-5 to T-2. His posterior neck had extensive abrasions, which had to be debrided before making the dorsal incision.

**Postoperative Course.** Postoperatively, he had full strength in bilateral deltoids and biceps, movement with gravity eliminated in bilateral triceps, twitch movement in bilateral hand grip, and complete paralysis in both legs. He was placed on piperacillin/tazobactam for 1 week for prophylactic postoperative antibiotic coverage because of the significant dermal abrasions.

**Complications and Outcome.** Three weeks later, he had dehiscence of his posterior cervical wound. Follow-up MRI studies showed posterior and anterior fluid collections at the operative sites (Fig. 2). He was taken for irrigation and debridement of both wounds. The bone graft material was removed, but the titanium hardware was left in place. Significant purulence was found, and intraoperative cultures were sent. A Gram stain was negative for all wound cultures. He was started on vancomycin and meropenem for broad-spectrum antibiotic coverage.

One week later, he developed new bicep and deltoid weakness with fever of 38.3°C and leukocytosis of 11,500 cells/dl. Anterior and posterior cervical wounds were flat, without erythema or drainage. An MRI study was obtained, which showed an intramedullary spinal cord rim-enhancing lesion with extensive increased T2 signal extending up to the medulla, which was of concern for intramedullary spinal cord abscess (Fig. 3). He was taken to the operating room for emergency evacuation of the rim-enhancing lesion. A midline myelotomy was performed to enter the collection, which was purulent. It was then debrided from the inside out. Care was taken to remain within the collection without removing neural tissue. Cultures were sent and the Gram stain remained negative. Postoperatively, antibiotic coverage was broadened with the addition of metronidazole.
Four days later, the cultures from the first wound irrigation and debridement grew *M. hominis*. This was 10 days after the operation. Antibiotics were changed to vancomycin, moxifloxacin, and doxycycline for 1 week. Without growth of other organisms, antibiotic monotherapy was implemented with intravenous moxifloxacin. Serial follow-up MRI showed improvement in the cord signal and good response to the antibiotics. He regained his biceps and deltoid strength to the same level he had demonstrated on his best initial examination. He was transferred to an inpatient spinal cord rehabilitation center. Antibiotic coverage was transitioned to oral moxifloxacin, which was continued for 6 months. At 1-year follow-up, he has remained free of recurrent infection, with stable results on postoperative examination and imaging (Fig. 4).

**Methods**

PubMed was queried using the search terms “*Mycoplasma hominis*, -meningitis, -cranial, -infection, -trauma, -neurosurgery, -immunocompromised, -steroids, -postoperative, and intramedullary spinal cord abscess.” Nine papers discussing postneurosurgical *M. hominis* infections were identified.

**Results**

Through the literature review, 11 patients were identified who developed brain or spine infections from *M. hominis* after neurosurgical procedures; clinical details are outlined in Table 1. All patients underwent Foley catheterization, and 27% had genitourinary risk factors other than urinary catheterization. The mean time to diagnosis after the original procedure was 22 days, with a range of 11–36 days. Five patients (45%) required 2 or more washout surgeries, and 1 patient required 4 procedures before diagnosis was made and appropriate antibiotics were started. No further washout surgeries were needed after appropriate antibiotics were started, and in all cases multiple different antibiotics were used unsuccessfully before diagnosis. After diagnosis, most patients were treated with doxycycline and/or a fluoroquinolone with good success.

![Fig. 2. Cervical spine MRI studies showing the anterior and posterior wound infections before the first washout surgery. A: Sagittal T1-weighted image. B: Axial T1-weighted image with contrast showing the extent of the anterior collection. C: Axial T1-weighted image with contrast showing the extent of the posterior collection.](image)

![Fig. 3. Cervical spine MRI studies showing the intramedullary abscess. Left: Sagittal T1-weighted image with contrast showing the rim-enhancing lesion within the spinal cord. Right: Sagittal STIR image showing the extent of spinal cord signal extending superiorly into the medulla.](image)
Postneurosurgical M. hominis infections

Mycoplasma hominis Spine Infections

To the best of our knowledge, there are no other reported intramedullary spinal cord infections with M. hominis in the literature. In intramedullary infections they are themselves a rare entity carrying significant morbidity. In a review of 25 cases, Chan and Gold reported an 8% mortality rate (both of these patients also had brain abscesses) and a 70% rate of persistent neurological deficit in patients with this condition. Multiple organisms were implicated. In some cases, no organism was identified. Causes included dermal sinus tracts, epidermoid cysts, hematogenous spread, and postoperative infections. The majority remained cryptogenic. Of the 25 cases, 1 underwent a myelotomy for drainage of the abscess, 1 had needle drainage, and 3 were treated based on systemic culture results.

There are 2 cases of postoperative extramedullary M. hominis spinal infections reported. The first was a 38-year-old woman who presented 1 month after L4/5 disc replacement with fever to 39°C, C-reactive protein of 120, and a mildly elevated WBC count of 10,900/dl. Imaging revealed a deep wound infection. Culture revealed M. hominis after 4 days. Although she did have chronic UTIs due to her myelomeningocele, M. hominis was never isolated from urine specimens. She was successfully treated with doxycycline.

Mycoplasma hominis Brain Infections

There are a few cases in which patients developed subdural empyemas after surgical evacuation of traumatic subdural hematomas. In all cases, there was a delayed diagnosis. In some patients multiple irrigation and debridement procedures were required before adequate antibiotic treatment was established. Patients were successfully treated with doxycycline, tetracycline, gatifloxacin, moxifloxacin, or erythromycin.

There is 1 report of a postoperative brain abscess from M. hominis following elective cavernoma resection. The patient was afebrile with a normal WBC count, and presented with speech changes and left-sided weakness. She had a recent episode of vulvar irritation. 11 The patient was afebrile with a normal WBC count, but presented with speech changes and left-sided weakness. She had a recent episode of vulvar irritation.

Another paper reports a patient with fever and mental status changes after an elective colloid cyst resection. Cerebrospinal fluid Gram stain was negative. The patient was taken for wound irrigation and debridement with removal of the bone flap. The patient subsequently experienced further deterioration with the development of a subdural empyema. The empyema was evacuated and an external ventricular drain (EVD) was placed. Due to persistent fevers, 2 additional irrigation and debridement procedures were performed. Finally, on Day 36, M. hominis grew in a subdural culture. Review of prior cultures showed presence of the organism, which had been missed on laboratory analysis. After treatment was changed to gatifloxacin and clindamycin, the infection resolved.

Finally, there are 3 cases of EVDs that were infected with M. hominis. In 1 case, the patient also had a craniotomy for clip occlusion of a ruptured middle cerebral artery aneurysm, so the procedure that resulted in the infection cannot be determined. After delay in diagnosis because of initially negative cultures, appropriate antibiotic therapy effectively treated the infections. In 1 case the patient had a large intracerebral hemorrhage, and the family declined antibiotic treatment due to the prognosis from the hemorrhage. This patient subsequently died.

The Role of Immunosuppression in M. hominis Infections

Because M. hominis is a common colonizer of the genitourinary system but a rare cause of CNS infections, we hypothesized that immunosuppression may play a role in cases of extragenital infection. Given the small number of cases, even among immunosuppressed patients, it is difficult to answer the question clearly. There is a correlation with cell-mediated immune compromise and hypogam-

Fig. 4. Most recent cervical spine MRI study. This sagittal T2-weighted image shows improvement in the spinal cord signal and no signs of recurrent abscess. There is notable spinal cord atrophy due to the injury.
TABLE 1: Clinical characteristics of postneurosurgical *M. hominis* infections*

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Pt Age (yrs), Sex</th>
<th>Procedure</th>
<th>Days to Dx After Original Op</th>
<th>No. of Ops for Infection</th>
<th>Antibiotics Used Prior to Dx</th>
<th>Final Antibiotic Regimen</th>
<th>Risk Factors Other Than Urinary Catheter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payan et al., 1981</td>
<td>29, M</td>
<td>craniotomy for SDH &amp; cerebral contusion evacuation after MVC</td>
<td>23</td>
<td>1</td>
<td>oxacillin, cephalothin, nafcillin, chloramphenicol</td>
<td>tetracycline then erythromycin due to adverse drug reaction</td>
<td>trauma, dexamethasone (16 mg daily for 10 days)</td>
</tr>
<tr>
<td>McMahon et al., 1990</td>
<td>76, M</td>
<td>EVD for spontaneous ICH</td>
<td>11</td>
<td>0</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Cohen &amp; Kubak, 1997</td>
<td>18, F</td>
<td>bilat EVDs after MVC</td>
<td>20</td>
<td>0</td>
<td>erythromycin</td>
<td>doxycycline, ciprofloxacin, chloramphenicol</td>
<td>none reported</td>
</tr>
<tr>
<td>House et al., 2003</td>
<td>40, F</td>
<td>elective craniotomy for cavernoma resection</td>
<td>12 + “several”</td>
<td>2</td>
<td>vancomycin, cefotaxime, metronidazole</td>
<td>ciprofloxacin, metronidazole</td>
<td>vulvar ulceration</td>
</tr>
<tr>
<td>McCarthy &amp; Looke, 2008</td>
<td>48, F</td>
<td>elective colloid cyst resection</td>
<td>36</td>
<td>4 washouts plus EVD</td>
<td>ceftazidime, vancomycin</td>
<td>gatifloxacin, then clindamycin</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>17, F</td>
<td>decompressive craniotomy after MVC</td>
<td>17</td>
<td>prior washouts for persistent infection: 1 cranial, 2 orthopedic</td>
<td>vancomycin, meropenem</td>
<td>gatifloxacin, then moxifloxacin</td>
<td>none</td>
</tr>
<tr>
<td>Lee et al., 2012</td>
<td>48, F</td>
<td>ruptured MCA aneurysm dipping &amp; EVD</td>
<td>15</td>
<td>2</td>
<td>flucloxacillin, vancomycin (IV &amp; IT)</td>
<td>moxifloxacin</td>
<td>none reported</td>
</tr>
<tr>
<td>Henao-Martínez et al., 2012</td>
<td>40, M</td>
<td>craniotomy for SDH evacuation after MVC</td>
<td>17</td>
<td>2</td>
<td>vancomycin, piperacillin/tazobactam, ceftriaxone, metronidazole</td>
<td>doxycycline</td>
<td>trauma</td>
</tr>
<tr>
<td>Krijnen et al., 2006</td>
<td>11, F</td>
<td>T3–L5 instrumented posterior fusion for scoliosis</td>
<td>22</td>
<td>1</td>
<td>cefazolin, cefradine, gentamicin collagen fleeces, gentamicin, fluvoxacin</td>
<td>doxycycline</td>
<td>chronic UTIs status post bladder augmentation</td>
</tr>
<tr>
<td>Flouzat-Lachaniette et al., 2013</td>
<td>38, F</td>
<td>elective L4/5 disc replacement</td>
<td>35</td>
<td>1</td>
<td>cefuroxime, cefotaxime, fosfomycline</td>
<td>doxycycline</td>
<td>abnormal vaginal discharge w/ IUD (device culture negative for <em>M. hominis</em>), intraop peritoneal breach</td>
</tr>
<tr>
<td>present study</td>
<td>17, M</td>
<td>instrumented posterior &amp; anterior cervical spinal fusions after MVC</td>
<td>32</td>
<td>2</td>
<td>piperacillin/tazobactam, vancomycin, ceftriaxone, metronidazole</td>
<td>doxycycline, moxifloxacin</td>
<td>trauma, methylprednisolone</td>
</tr>
</tbody>
</table>

* Dx = diagnosis; ICH = intracerebral hemorrhage; IT = intrathecal; IV = intravenous; MCA = middle cerebral artery; Pt = patient; SDH = subdural hematoma.
Postneurosurgical *M. hominis* infections

maglobulinemia. Meyer and Clough report that in 67 patients with *M. hominis* infection, 32 had one of these risk factors. Patients with transplants, many of whom are on long-term corticosteroid regimens, are in this group. In our case, the patient was given the methylprednisolone protocol for acute SCI, and it is possible that this made him more susceptible to the *M. hominis* infection.

**Discussion**

**Genitourinary Tract and Oropharyngeal Colonization as Cause of *M. hominis* Abscesses**

Because *M. hominis* is known to colonize the genitourinary tracts of healthy patients, many papers claim that postoperative or trauma-related *M. hominis* infections are caused by injury to these structures by Foley catheter placement. This causes a transient bacteremia that can seed hematomas or surgical cavities. In our case, the urinalysis showed blood but no bacteria. *Mycoplasma hominis* would not have been detected as a bacterium by this test, but the presence of blood indicates a possible route for hematogenous spread if the genitourinary tract had been colonized.

Several case reports in the literature are used to support this theory. There are many cases of patients with multiple traumas who subsequently developed *M. hominis* abscesses outside the genitourinary system. These patients all underwent Foley catheterization. There are multiple cases of *M. hominis* brain abscesses in mothers following normal vaginal deliveries and cesarean sections. There is a case of *M. hominis* brain abscess developing after a uterine curettage. There are multiple reports of cases of neonatal meningitis that are attributed to scalp monitoring or to instrumented deliveries exposing infants to their mother's vaginal flora.

Unfortunately, there is a lack of culture data from the genitourinary tracts of patients with *M. hominis* abscesses. Even in cases of frank infection, cultures do not always grow *M. hominis*, and the likelihood of obtaining reliable culture data in an area colonized with fewer organisms could be even lower. Although Foley catheterization was once a risk factor for colonized patients, a significant number of surgical patients with Foley catheters must be colonized but never develop these infections. It is possible that some colonized patients harbor strains of *M. hominis* that are more virulent than others, making infection more likely in this subset. This hypothesis, however, is not supported by any current laboratory data. Finally, to show that an infection came from a patient's own flora and not from an iatrogenic source, positive cultures or PCR data would have to be obtained prior to any intervention. This is unlikely ever to be studied due to the low rate of extragenitourinary *M. hominis* infection.

The hypothesis that these infections are caused by hematogenous spread of native organisms is supported by significant circumstantial evidence but no definitive culture or PCR data. It also remains possible that *M. hominis* is simply an uncommon cause of iatrogenic infection during invasive procedures.

**Diagnosis and Management**

Diagnosis of *M. hominis* infections in the postoperative period is difficult. *Mycoplasma hominis* is a slow-growing organism that cannot be detected easily by routine techniques. Time from initial procedure to diagnosis ranges from 11 days to 5 weeks in the literature. Because all patients in our series improved with appropriate antibiotic treatment, we believe that early broadening of antibiotics with PCR testing for *Mycoplasma* and *Ureaplasma* species is prudent when treating a patient with persistent signs of infection or abscess recurrence but negative cultures. This should include either doxycycline or a fluoroquinolone. Of the fluoroquinolones tested for CSF penetration in 1 article, moxifloxacin and gatifloxacin showed significantly higher CSF penetration than trovafloxacin, levofloxacin, or ciprofloxacin. Gatifloxacin has been associated with significant hypoglycemia and is unavailable in many markets, so moxifloxacin is probably the best choice of these agents.

An additional surgical concern is whether to remove spinal hardware when a postoperative infection develops. In this case, titanium instrumentation was used, which is generally resistant to microbial colonization. We decided to leave the hardware in place after irrigation and debridement to maintain spinal stability and minimize the risk of further neurological injury. The 2 cases involving implants reported in the literature include an artificial lumbar disc and a multilevel instrumentation for scoliosis. The artificial disc was Mobidisc, a construct composed of a polyethylene layer sandwiched between 2 titanium plates. The scoliosis surgery was performed with the Stryker Xia system. The article did not specify which model of Xia was used, although both stainless steel and titanium submodels are available. In both cases the hardware was left in place, and the infection was managed adequately with antibiotics. Our experience also suggests that *M. hominis* infections can be successfully treated without removing spinal implants.

**Immunosuppression Regimens**

Our patient was placed on the methylprednisolone protocol for SCI, and this may have contributed to his infection. There are no other case reports of this protocol causing spinal *M. hominis* infection, but immunosuppression regimens including those with corticosteroids have been linked to *M. hominis* infections. With new SCI guidelines recommending against the methylprednisolone protocol, we do not plan to use it in the future.

In our review, at least 1 patient who developed an *M. hominis* brain abscess was placed on high-dose dexamethasone for cerebral edema. In most articles, there was no comment on the use of steroids, so it is unclear whether steroid use is a common factor in intracranial *M. hominis* infections.

**Conclusions**

*Mycoplasma hominis* is a rare cause of postoperative infections in the neurosurgical population. It is difficult to diagnose, and cultures take at least several days to yield a positive result. Typical broad-spectrum antibiotics such as vancomycin, ceftriaxone, clindamycin, and metronidazole are ineffective against *M. hominis*. Because of
the difficulty in diagnosing and treating this organism, *M. hominis* infection can lead to significant morbidity, including neurological decline, multiple returns to the operating room, and prolonged hospitalization before the correct diagnosis is made and appropriate therapy is initiated. Fortunately, *M. hominis* is very responsive to appropriate antibiotic therapy, and neurological deficits incurred with infection are often reversible with aggressive treatment. *Mycoplasma hominis* should be suspected in any case in which a postoperative patient remains persistently febrile with elevated WBC cell count or C-reactive protein while on broad-spectrum antibiotics without coverage for atypical bacteria like *M. hominis*. Early culture on blood agar or PCR may help with definitive diagnosis. Moxifloxacin may be the antibiotic of choice to treat *M. hominis* infection of the brain or spinal cord because of its increased CSF penetration compared with other fluoroquinolone antibiotics.

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**Disclosure**

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following: Conception and design: Whitson, Bauer. Acquisition of data: all authors. Analysis and interpretation of data: Whitson. Drafting the article: Whitson. 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: Whitson. Administrative/technical/material support: Balkman. Study supervision: Bauer.

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