Practice Advisory for the Prevention, Diagnosis, and Management of Infectious Complications Associated with Neuraxial Techniques

*An Updated Report by the American Society of Anesthesiologists Task Force on Infectious Complications Associated with Neuraxial Techniques and the American Society of Regional Anesthesia and Pain Medicine**

PRACTICE advisories are systematically developed reports that are intended to assist decision-making in areas of patient care. Advisories provide a synthesis of scientific literature and analysis of expert opinion, clinical feasibility data, open forum commentary, and consensus surveys. Practice advisories developed by the American Society of Anesthesiologists (ASA) are not intended as standards, guidelines, or absolute requirements, and their use cannot guarantee any specific outcome. They may be adopted, modified, or rejected according to clinical needs and constraints, and they are not intended to replace local institutional policies.

Practice advisories summarize the state of the literature and report opinions obtained from expert consultants and ASA members. They are not supported by scientific literature to the same degree as standards or guidelines because of the lack of sufficient numbers of adequately controlled studies. Practice advisories are subject to periodic revision as warranted by the evolution of medical knowledge, technology, and practice.

This document updates the "Practice Advisory for the Prevention, Diagnosis, and Management of Infectious Complications Associated with Neuraxial Techniques by the ASA Task Force on Infectious Complications Associated with Neuraxial Techniques," adopted by ASA in 2009 and published in 2010.†

Methodology

Definition of Infectious Complications Associated with Neuraxial Techniques

For this Advisory, *infectious complications* are defined as serious infections associated with the use of neuraxial techniques. Neuraxial techniques include, but are not limited to, epidural, spinal, or combined spinal-epidural administration of anesthetics, analgesics, or steroids; lumbar puncture/spinal tap; epidural blood patch; epidural lysis of adhesions; intrathecal chemotherapy; epidural or spinal injection of contrast agents for imaging; lumbar/spinal drainage catheters; or spinal cord stimulation trials. Infectious complications include, but are not limited to, epidural, spinal, or subdural abscess; paravertebral, paraspinous, or psoas abscess; meningitis; encephalitis; sepsis; bacteremia; viremia; fungemia; osteomyelitis; or discitis. Although colonization of the catheter is not considered an infection, it may be considered a *precursor* to infection, and is reported as an outcome in this Advisory.

Purpose of the Advisory

The purposes of this updated Advisory are to reduce the risk of infectious complications associated with neuraxial techniques by identifying or describing: (1) patients who are at increased risk of infectious complications, (2) techniques for reducing

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†American Society of Anesthesiologists Task Force on infectious complications associated with neuraxial techniques: Practice advisory for the prevention, diagnosis, and management of infectious complications associated with neuraxial techniques: A report by the American Society of Anesthesiologists Task Force on infectious complications associated with neuraxial techniques. ANESTHESIOLOGY 2010; 112:530–45

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infectious risk, and (3) interventions to improve outcomes after infectious complications.

Focus

This updated Advisory focuses on patients receiving neuraxial techniques. The practice settings include inpatient (*e.g.,* operating rooms, intensive care units, postoperative surgical floors, labor and delivery settings, or hospital wards) and ambulatory facilities such as pain clinics.

This updated Advisory does not address patients with implantable drug or chronic indwelling neuraxial analgesic delivery systems or injection techniques outside of the neuraxis (*e.g.,* peripheral nerve blocks or joint and bursal injections).

Application

This updated Advisory is intended for use by anesthesiologists and other physicians and health care providers performing neuraxial techniques. The Advisory may also serve as a resource for other health care providers involved in the management of patients who have undergone neuraxial procedures.

Task Force Members and Consultants

In 2015, the ASA Committee on Standards and Practice Parameters requested that scientific evidence for this Advisory be updated. The update consists of an evaluation of literature that includes new studies obtained after publication of the original Advisory.

The original Advisory was developed by an ASA-appointed Task Force of 10 members, including anesthesiologists in both private and academic practice from various geographic areas of the United States and two consulting methodologists from the ASA Committee on Standards and Practice Parameters.

The Task Force developed the original Advisory by means of a seven-step process. First, they reached consensus on the criteria for evidence. Second, a systematic review and evaluation was performed on original published research studies from peer-reviewed journals relevant to infectious complications associated with neuraxial techniques. Third, a panel of expert consultants was asked to participate in opinion surveys on the effectiveness of various strategies for prevention, diagnosis, and management of infectious complications associated with neuraxial techniques, and to review and comment on a draft of the Advisory. Fourth, opinions about the Advisory were solicited from a random sample of active members of the ASA. Fifth, the Task Force held open forums at four major national meetings[‡] to solicit input on its draft advisory statements. Sixth, the consultants were surveyed to assess their opinions on the feasibility of implementing the Advisory. Seventh, all available information was used to build consensus within the Task Force to formulate the final document. A summary of recommendations is found in appendix 1.

Availability and Strength of Evidence

Preparation of this update used the same methodological process as was used in the original Advisory to obtain new scientific evidence. Opinion-based evidence obtained from the original Advisory is reported in this update. The protocol for reporting each source of evidence is described below.

Scientific Evidence. Scientific evidence used in the development of this updated Advisory is based on cumulative findings from literature published in peer-reviewed journals. Literature citations are obtained from health care databases, direct Internet searches, Task Force members, liaisons with other organizations, and manual searches of references located in reviewed articles.

Findings from the aggregated literature are reported in the text of the updated Advisory by evidence category, level, and direction. Evidence categories refer specifically to the strength and quality of the *research design* of the studies. Category A evidence represents results obtained from randomized controlled trials (RCTs) and Category B evidence represents observational results obtained from nonrandomized study designs or RCTs without pertinent comparison groups. When available, Category A evidence is given precedence over Category B evidence for any particular outcome. These evidence categories are further divided into evidence levels. Evidence levels refer specifically to the strength and quality of the summarized study *findings* (*i.e.,* statistical findings, type of data, and the number of studies). In this document, only the highest level of evidence is included in the summary report for each intervention-outcome pair, including a directional designation of benefit, harm, or equivocality for each outcome.

Category A. RCTs report comparative findings between clinical interventions for specified outcomes. Statistically significant ($P < 0.01$) outcomes are designated as either beneficial (B) or harmful (H) for the patient; statistically nonsignificant findings are designated as equivocal (E).

Level 1: The literature contains a sufficient number of RCTs to conduct meta-analysis,[§] and meta-analytic findings from these aggregated studies are reported as evidence.

Level 2: The literature contains multiple RCTs, but the number of RCTs is not sufficient to conduct a viable meta-analysis. Findings from these RCTs are reported separately as evidence.

‡ American Society of Regional Anesthesia, Huntington Beach, California, November 22, 2008; Postgraduate Assembly in Anesthesiology, New York, New York, December 13, 2008; American Society of Regional Anesthesia, Phoenix, Arizona, May 1, 2009; Society of Obstetrical Anesthesia and Perinatology, Washington, DC, May 1, 2009.

§ All meta-analyses are conducted by the ASA methodology group. Meta-analyses from other sources are reviewed but not included as evidence in this document.

Level 3: The literature contains a single RCT and findings are reported as evidence.

Category B. Observational studies or RCTs without pertinent comparison groups may permit *inference* of beneficial or harmful relationships among clinical interventions and clinical outcomes. Inferred findings are given a directional designation of beneficial (B), harmful (H), or equivocal (E). For studies that report statistical findings, the threshold for significance is $P < 0.01$.

Level 1: The literature contains observational comparisons (*e.g.,* cohort, case-control research designs) with comparative statistics between clinical interventions for a specified clinical outcome.

Level 2: The literature contains noncomparative observational studies with associative statistics (*e.g.,* relative risk, correlation, sensitivity/specificity).

Level 3: The literature contains noncomparative observational studies with descriptive statistics (*e.g.,* frequencies, percentages).

Level 4: The literature contains case reports.

Insufficient Literature. The *lack* of sufficient scientific evidence in the literature may occur when the evidence is either unavailable (*i.e.,* no pertinent studies found) or inadequate. Inadequate literature cannot be used to assess relationships among clinical interventions and outcomes because a clear interpretation of findings is not obtained due to methodological concerns (*e.g.,* confounding of study design or implementation) or the study does not meet the inclusion criteria for content as defined in the "Focus" of the Advisory.

Opinion-based Evidence. All opinion-based evidence (*e.g.,* survey data, open-forum testimony, Internet-based comments, letters, and editorials) relevant to each topic was considered in the development of this updated Advisory. However, only the findings obtained from formal surveys are reported in the current update.

Opinion surveys were developed to address each clinical intervention identified in the document. Identical surveys were distributed to expert consultants and a random sample of ASA members.

Category A: Expert Opinion. Survey responses from Task Force–appointed expert consultants are reported in summary form in the text, with a complete listing of consultant survey responses reported in a table in appendix 2.

Category B: Membership Opinion. Survey responses from a random sample of active members of the ASA are reported in summary form in the text, with a complete listing of responses reported in appendix 2.

Survey responses from expert and membership sources are recorded using a 5-point scale and summarized based on median values.**

Strongly Agree: Median score of 5 (at least 50% of the responses are 5)

Agree: Median score of 4 (at least 50% of the responses are 4 or 4 and 5)

Equivocal: Median score of 3 (at least 50% of the responses are 3, or no other response category or combination of similar categories contain at least 50% of the responses)

Disagree: Median score of 2 (at least 50% of responses are 2 or 1 and 2)

Strongly Disagree: Median score of 1 (at least 50% of responses are 1)

Category C: Informal Opinion. Open-forum testimony obtained during development of the original Advisory, Internet-based comments, letters, and editorials are all informally evaluated and discussed during the formulation of Advisory statements. When warranted, the Task Force may add educational information or cautionary notes based on this information.

Advisories

Prevention of Infectious Complications Associated with Neuraxial Techniques

Topics addressed with regard to the prevention of infectious complications related to neuraxial techniques are as follows: (1) conducting a history, physical examination and preprocedure laboratory evaluation, (2) use and selection of neuraxial technique, (3) prophylactic antibiotic therapy, (4) physician use of aseptic techniques, (5) selection of antiseptic solution, (6) use of individual antiseptic packets, (7) use of sterile occlusive dressings at the catheter insertion site, (8) use of a bacterial filter during continuous epidural infusion, (9) limiting disconnection and reconnection of neuraxial delivery systems, (10) management of an accidentally disconnected catheter, and (11) limiting the duration of catheterization. *Advisory statements for the above topics are reported below after descriptions of the evidence for all eleven topics.*

History, Physical Examination, and Preprocedure Laboratory Evaluation.

Literature findings. Although no controlled trials were found that addressed the impact of conducting a focused history (*e.g.,* reviewing medical records), a physical examination, or a preprocedure laboratory evaluation, several studies with observational findings suggest that certain patient or clinical characteristics (*e.g.,* cancer, diabetes, and impaired immune response) may be associated with neuraxial-related infections *(Category B3-H evidence)*.[1–11] In addition, case reports indicate that preexisting infections, pancreatitis, gastrointestinal bleeding, drug or alcohol abuse may also be associated with neuraxial-related infections *(Category B4-H evidence)*.[12–34]

Survey findings. Both the consultants and ASA members strongly agree that a history, physical examination, and review of relevant laboratory studies should be conducted prior to performing neuraxial techniques. The consultants agree and ASA members strongly agree that before performing

** When an equal number of categorically distinct responses are obtained, the median value is determined by calculating the arithmetic mean of the two middle values. Ties are calculated by a predetermined formula.

neuraxial techniques, a history, physical examination, and review of relevant laboratory studies is useful in identifying patients at increased risk of infectious complications.

Selection of Neuraxial Technique. The risk of developing infectious complications associated with specific neuraxial techniques is addressed by making the following comparisons: (1) epidural *versus* spinal techniques, (2) continuous infusion/catheter *versus* single injection techniques, (3) lumbar epidural *versus* thoracic epidural techniques, and (4) lumbar epidural *versus* caudal techniques.

Literature findings. No RCTs were found that reported differences between specific neuraxial techniques regarding infectious complications. One nonrandomized comparative study reports no significant differences in bacterial contamination of needles when epidural lumbar puncture is compared with spinal lumbar puncture *(Category B1-E evidence)*.[35] The literature is insufficient to evaluate differences in infectious complications between continuous infusion/catheter and single injection techniques. One case control study found no differences in epidural catheter infections when the lumbar insertion technique is compared with the thoracic insertion technique *(Category B1-E evidence)*.[36] Three nonrandomized comparative studies report no statistically significant ($P > 0.01$) differences in bacterial colonization of the catheter tip when the lumbar insertion site is compared with the caudal insertion site *(Category B1-E evidence)*.[37–39]

Survey findings. Both the consultants and ASA members strongly agree that, for patients at risk of infectious complications, the decision to select a neuraxial technique should be determined on a case-by-case basis. The consultants agree and ASA members strongly agree that, for these patients, alternatives to neuraxial techniques should be considered. Moreover, both the consultants and ASA members strongly agree that the evolving medical status of the patient should be considered in the selection of neuraxial technique. Both the consultants and ASA members strongly agree that a lumbar puncture should be avoided in a patient with a known epidural abscess.

Prophylactic Antibiotic Therapy.

Literature findings. The literature is insufficient to assess whether prophylactic antibiotic therapy for known or suspected bacteremic patients reduces the risk of infectious complications associated with neuraxial techniques. Case reports indicate that infectious complications in these patients may still occur even when prophylactic antibiotic therapy is administered *(Category B4-E evidence)*.[12,40,41]

Survey findings. Both the consultants and ASA members strongly agree that, when a neuraxial technique is selected in a known or suspected bacteremic patient, preprocedure antibiotic therapy should be administered.

Physician Use of Aseptic Techniques.

Literature findings. An RCT reports no difference in catheter tip colonization when sterile gowns are worn compared with not wearing sterile gowns during epidural catheter insertion *(Category A3-E evidence)*.[42] The literature is insufficient regarding the efficacy of other aseptic techniques during neuraxial procedures (*e.g.,* removal of jewelry, hand washing, and wearing of caps, masks, and sterile gloves) in reducing infectious complications. Case reports indicate that infections can occur when aseptic techniques are not fully followed *(Category B4-H evidence)*.[43–48] However, studies with observational findings indicate that infections may still occur even when aseptic techniques are used *(Category B3-E evidence)*[49–52] and additional case reports indicate similar outcomes *(Category B4-E evidence)*.[14,21,27–29,33,53–73]

Survey findings. Both the consultants and ASA members strongly agree that aseptic techniques should always be used during the placement of neuraxial needles and catheters, including hand washing, wearing of sterile gloves, wearing of caps, wearing of masks covering both the mouth and nose, and sterile draping of the patient. In addition, both the consultants and ASA members agree that aseptic techniques should include removal of jewelry, and they are equivocal regarding the wearing of gowns. Finally, the consultants agree and ASA members are uncertain regarding whether aseptic techniques should include changing masks before each new case.

Selection of Antiseptic Solution. Selection of antiseptic solution includes: (1) chlorhexidine *versus* povidone iodine, and (2) aseptic preparation with alcohol *versus* without alcohol.

Literature findings. An RCT reports no difference in the rate of positive bacteriologic cultures on the catheter tip or injection site when chlorhexidine is compared with povidone-iodine; nor is a difference reported when alcohol is added to these skin disinfectants *(Category A3-E evidence)*.[74] Additional findings reported in this study comparing chlorhexidine with alcohol or povidone-iodine with alcohol versus these disinfectants alone are also equivocal *(Category A3-E evidence)*. Findings of other RCTs are inconsistent regarding the rate of positive bacteriologic cultures when chlorhexidine with alcohol is compared with povidone-iodine without alcohol *(Category A2-B evidence)*.[75–78]

Survey findings. The consultants indicate a preference for chlorhexidine with alcohol as a skin preparation solution prior to performing a neuraxial technique, while the ASA members indicate no clear preference for chlorhexidine with or without alcohol, or povidone-iodine with or without alcohol.

Use of Individual Antiseptic Packets.

Literature findings. Although the literature is insufficient regarding whether the use of individual antiseptic packets compared with multiple-use bottles of antiseptic reduces infectious complications, an observational study reports no microbial contamination when unopened multiple-use bottles of povidone-iodine are used, compared to evidence of contamination found with previously opened multiple-use bottles *(Category B1-B evidence)*.[79] A case report indicated lumbar spondylodiscitis occurring in a patient whose skin was cleansed with povidone-iodine obtained from a multiple-use bottle *(Category B4-H evidence)*.[80]

Survey findings. Both the consultants and ASA members strongly agree that individual packets of skin preparation should always be used.

Use of Sterile Occlusive Dressings at the Catheter Insertion Site.

Literature findings. No comparative studies were found that indicate whether the use of sterile occlusive dressings at the catheter insertion site reduces infectious complications. Observational studies indicate that positive cultures may still occur with the use of sterile occlusive dressings *(Category B3-E evidence)*[81,82] and case reports indicate similar outcomes *(Category B4-E evidence)*.[29,63,83,84]

Survey findings. Both the consultants and ASA members strongly agree that sterile occlusive dressings should be used at the catheter insertion site.

Use of a Bacterial Filter during Continuous Epidural Infusion.

Literature findings. No comparative studies were found that indicates whether the use of bacterial filters reduce infectious complications. One nonrandomized comparative study found that use of a bacterial filter during continuous epidural infusion does not reduce the number of *positive cultures* distal to the filter *(Category B1-E evidence)*.[85] Studies with observational findings indicate that bacterial colonization may still occur in the presence of micropore filters *(Category B2-E evidence)*.[49,82,86] In addition, case reports indicate that infectious complications (*e.g.,* epidural abscess) may still occur in the presence of bacterial filters *(Category B4-E evidence)*.[14,30,53,60,67,74,81,87–90]

Survey findings. The ASA members agree and the consultants are uncertain regarding whether bacterial filters should be used during continuous epidural infusion.

Limiting Disconnection and Reconnection of Neuraxial Delivery Systems.

Literature findings. The literature is insufficient to evaluate whether limiting disconnection or reconnection of neuraxial delivery systems are associated with reduced frequency of infectious complications.

Survey findings. Both the consultants and ASA members strongly agree that disconnection and reconnection of neuraxial delivery systems should be limited in order to minimize the risk of infectious complications.

Management of an Accidentally Disconnected Catheter.

Literature findings. The literature is insufficient to evaluate whether removal of an accidentally disconnected catheter is associated with reduced frequency of infectious complications.

Survey findings. ASA members are equivocal and the consultants disagree that accidently disconnected catheters should be immediately removed. However, the Task Force believes that, in order to avoid infectious complications, an *unwitnessed* accidently disconnected catheter should be removed.

Limiting the Duration of Catheterization.

Literature findings. No comparative studies were found that indicate whether longer duration of catheterization is associated with increased frequency of infectious complications. Studies with observational findings indicate that infections and epidural abscesses may occur in the presence of longer durations *(Category B3-H evidence)*[2,8,91–98] and case reports corroborate these findings *(Category B4-H evidence)*.[15,18,19,24,53,99–103] No literature was found that identified a specific duration of catheterization associated with an increased risk of infectious complications.

Survey findings. Both the consultants and ASA members strongly agree that catheters should not remain *in situ* longer that clinically necessary.

Advisory Statements for Prevention

- Before performing neuraxial techniques, conduct a history and physical examination relevant to the procedure and review relevant laboratory studies[††] in order to identify patients who may be at risk of infectious complications.
- Consider alternatives to neuraxial techniques for patients at high risk.
- When neuraxial techniques are selected in a known or suspected bacteremic patient, consider administering preprocedure antibiotic therapy.
- Select neuraxial technique on a case-by-case basis, including a consideration of the evolving medical status of the patient.
- Avoid lumbar puncture in the patient with a known epidural abscess.
- Use aseptic techniques during preparation of equipment (*e.g.,* ultrasound) and the placement of neuraxial needles and catheters,[‡‡] including:
  - Removal of jewelry (*e.g.,* rings and watches)
  - Hand washing
  - Wearing of caps
  - Wearing of masks covering both mouth and nose
    - Consider changing masks before each new case.
  - Use of sterile gloves
  - Sterile draping of the patient
- Use individual packets of antiseptics for skin preparation.
- Use an antiseptic solution (*e.g.,* chlorhexidine with alcohol) for skin preparation, allowing for adequate drying time.[§§]

†† Ordering, conducting, or requiring routine laboratory studies may not be necessary.

‡‡ The Centers for Disease Control and Prevention and the American Society of Regional Anesthesia and Pain Medicine have also published recommendations regarding asepsis and management of patients undergoing neuraxial techniques. These are available at the CDC (http://www.cdc.gov/ncidod/dhqp/injectionSafetyPractices.html) and ASRA (http://www.asra.com/consensus-statements/3.html) web sites.

§§ Consult product labels for instructions regarding the proper use, application, and drying time for skin antiseptics.

- Use sterile occlusive dressings at the catheter insertion site.
- Bacterial filters may be considered during extended continuous epidural infusion.
- Limit the disconnection and reconnection of neuraxial delivery systems in order to minimize the risk of infectious complications.
- Consider removing unwitnessed accidentally disconnected catheters.
- Catheters should not remain *in situ* longer than clinically necessary.

Diagnosis of Infectious Complications Associated with Neuraxial Techniques

Topics addressing the diagnosis of infectious complications consist of: (1) periodically checking for signs/symptoms of infection (*e.g.,* erythema, tenderness, and fever), (2) ordering blood tests (*e.g.,* white blood cell count, sedimentation rate, and C-reactive protein), (3) ordering a culture or cerebral spinal fluid analysis, (4) ordering imaging studies (magnetic resonance imaging, computed tomography, and myelography), and (5) periodically checking patients' neurologic function. *Advisory statements for the above topics are reported below after descriptions of the evidence for all five topics.*

Periodically Checking for Signs/Symptoms of Infection.

Literature findings. Studies with observational findings[4,9,82,104–106] indicate that early signs and symptoms (*e.g.,* back pain, fever, headache, erythema, and insertion site signs) may occur in the presence of infectious complications, and additional symptoms (*e.g.,* stiff neck, photophobia, radiating pain, loss of motor function, and confusion) may indicate further development of infectious complications *(Category B3-B evidence***).* Case reports indicate similar outcomes *(Category B4-B evidence).*[13–16,18–25,29–31,41,43–46,53,54,57–60,62–67,71–73,81,87–90,99,101–103,107–143]

The Task Force notes that signs or symptoms can either manifest within a few hours or may not be apparent for weeks after neuraxial administration.

Survey findings. Both the consultants and ASA members strongly agree that periodic evaluation of patients for signs and symptoms (*e.g.,* fever, headache, backache, erythema, and tenderness at the insertion site) is essential for the early identification of infectious complications. They agree that signs and symptoms should be assessed once per day, and they strongly agree that signs and symptoms should be promptly attended to in order to minimize the impact of an infectious complication. Finally, they strongly agree that, if an infection is suspected, an *in situ* catheter should be immediately removed.

Periodically Checking Patients' Neurologic Function.

Literature findings. Case reports indicate that neurologic deficits (*e.g.,* motor and sensory loss and paraplegia) may indicate the presence of infectious complications *(Category B4-B evidence).*[9,14,29,108,110,117,126,128,132,144]

Survey findings. Both the consultants and ASA members strongly agree that, if an abscess is suspected or neurologic deficit is present, consultation with other appropriate specialties should be promptly obtained.

Ordering Blood Tests.

Literature findings. Numerous case reports indicate that blood tests (*e.g.,* white blood cell counts, sedimentation rates, and C-reactive protein) may be useful in identifying infection *(Category B4-B evidence).*[13,14,22,23,29,31,45,46,57–60,62–64,70–72,89,103,108,113,115,118,120,122,123,125,126,129,130,132,133,137,140,142]

Survey findings. Both consultants and ASA members agree that, if an infection is suspected, blood tests should be ordered.

Ordering a Culture or Cerebral Spinal Fluid Analysis.

Literature findings. Studies with observational findings indicate that cultures (*e.g.,* blood, skin, abscess, or cerebrospinal fluid) can be useful in identifying the causal agent (*e.g.,* viral, bacterial, or fungal) of the infectious complication *(Category B3-B evidence).*[4,9,52,82,94–96,106,145–150] Case reports indicate similar outcomes *(Category B4-B evidence).*[13–15,18–21,23–25,29–31,41,43–46,53,54,57,58,60,62–67,71,72,81,87–90,99,101–103,108–110,112,113,115,117–119, 121–127,129–134,136,137,139–144,151–155]

Survey findings. Both the consultants and ASA members strongly agree that, if an infection is suspected, the catheter tip should be cultured. In addition, they both agree that additional cultures should be obtained.

Ordering Imaging Studies.

Literature findings. Studies with observational findings indicate that conducting magnetic resonance imaging, computed tomography, or myelogram may be useful in identifying infectious complications (*e.g.,* epidural abscess, discitis, and osteomyelitis) *(Category B3-B evidence).*[9,156,157] Case reports indicate similar outcomes *(Category B4-B evidence).*[13–15,19,21,22,25,29,31,32,53,54,59,60,62–65,70,71,81,87,88,90,99,101,103,108–110,113,115–122,126–129,132–134,138,140,142–144,155,158–169]

Survey findings. Both the consultants and ASA members strongly agree that, if an abscess is suspected and a neurologic deficit is present, imaging studies should be performed.

Advisory Statements for Diagnosis

- Perform daily evaluation of patients with indwelling catheters for early signs and symptoms (*e.g.,* fever, backache, headache, erythema, and tenderness at the insertion site) of infectious complications throughout their stay in the facility.†††

*** For diagnostic studies, the "B" referring to patient benefit indicates that the disorder may be detectable using the stated diagnostic intervention.

††† Immunocompromised patients may not manifest typical signs and symptoms of infection.

- To minimize the impact of an infectious complication, promptly attend to signs or symptoms.
- If an infection is suspected:
  - Remove an *in-situ* catheter and consider culturing the catheter tip.
  - Order appropriate blood tests.
  - Obtain appropriate cultures.
  - If an abscess is suspected or neurologic dysfunction is present, perform imaging studies and promptly obtain consultation with other appropriate specialties.

Management of Infectious Complications

Topics addressed with regard to management or treatment of infectious complications include: (1) administration of antibiotics, (2) collaboration with appropriate specialists to determine optimal nonsurgical treatment, and (3) collaboration with a surgeon to determine whether surgical intervention or percutaneous drainage is necessary.

Administration of Antibiotics.

Literature findings. Case reports indicate that appropriate antibiotic therapy may be an effective treatment for infections *(Category B4-B evidence)*.[22,25, 29–31,45,46,53,54,57–60, 62,65,66,72,89,101,102,110,112,113,116,117,119,120,122,124–126,129,131,134, 136–142,144,155,164,170,171]

Survey findings. Both the consultants and ASA members strongly agree that appropriate antibiotic therapy should *always* be administered at the earliest sign or symptom of a serious infection.

Collaboration with Appropriate Medical Specialists to Determine Optimal Treatment.

Literature findings. The literature is insufficient to evaluate the impact of collaborating with appropriate medical specialists. A retrospective analysis of 57 cases of spinal epidural abscess reported that the use of either antibiotic therapy, percutaneous drainage, or surgical interventions were equally as effective regarding patient recovery *(Category B1-B evidence)*.[172] The Task Force believes that consultation with a physician with expertise in the diagnosis and treatment of infectious diseases should be considered. However, the Task Force recognizes that, even with prompt medical intervention, recovery may be poor or incomplete.

Survey findings. The consultants agree and ASA members strongly agree that a specialist or physician with expertise in the diagnosis and treatment of infectious diseases should be consulted at the first sign of a serious infection.

Collaboration with a Surgeon to Determine Whether Surgical Intervention Is Warranted.

Literature findings. No controlled studies were found that reported differences in neurologic outcome associated with either percutaneous drainage or surgical interventions. Case reports indicate that percutaneous drainage of an abscess may be effective in resolution of symptoms *(Category B4-B evidence)*.[13,100,173] Case reports also indicate that surgical interventions (*e.g.,* surgical drainage of an abscess, debridement, laminectomy) for an abscess may result in improved neurologic function, although in some cases motor or sensory deficits may persist *(Category B4-B evidence)*.[14,20,21,23,29,31,60,63–65,67,70,71, 81,87,88, 90,99,115,118,123,128,129,133,134,143,144,169,174]

Survey findings. Both the consultants and ASA members strongly agree that, if an abscess is present, surgical consultation should be obtained to determine whether percutaneous drainage of the abscess or surgery (*e.g.,* laminectomy) is warranted.

Advisory Statements for Management

- Administer appropriate antibiotic therapy at the earliest sign or symptom of a serious neuraxial infection.
- Consider consultation with a physician with expertise in the diagnosis and treatment of infectious diseases.
- If an abscess is present, obtain surgical consultation to determine whether percutaneous drainage of the abscess or surgery (*e.g.,* laminectomy) is warranted.

Appendix I: Summary of Advisory Statements

Prevention of Infectious Complications Associated with Neuraxial Techniques

- Before performing neuraxial techniques, conduct a history and physical examination relevant to the procedure and review relevant laboratory studies* in order to identify patients who may be at risk of infectious complications.
- Consider alternatives to neuraxial techniques for patients at high risk.
- When neuraxial techniques are selected in a known or suspected bacteremic patient, consider administering preprocedure antibiotic therapy.
- Select neuraxial technique on a case-by-case basis, including a consideration of the evolving medical status of the patient.
- Avoid lumbar puncture in the patient with a known epidural abscess.
- Use aseptic techniques during preparation of equipment (*e.g.,* ultrasound) and the placement of neuraxial needles and catheters,† including:

* Ordering, conducting, or requiring routine laboratory studies may not be necessary.

† The Centers for Disease Control and Prevention and the American Society of Regional Anesthesia and Pain Medicine have also published recommendations regarding asepsis and management of patients undergoing neuraxial techniques. These are available at the CDC (http://www.cdc.gov/ncidod/dhqp/injectionSafetyPractices.html) and ASRA (http://www.asra.com/consensus-statements/3.html) Web sites.

- Removal of jewelry (*e.g.,* rings and watches)
- Hand washing
- Wearing of caps
- Wearing of masks covering both mouth and nose
  - Consider changing masks before each new case.
- Use of sterile gloves
- Sterile draping of the patient

- Use individual packets of antiseptics for skin preparation.
- Use an antiseptic solution (*e.g.*, chlorhexidine with alcohol) for skin preparation, allowing for adequate drying time.‡
- Use sterile occlusive dressings at the catheter insertion site.
- Bacterial filters may be considered during extended continuous epidural infusion.
- Limit the disconnection and reconnection of neuraxial delivery systems in order to minimize the risk of infectious complications.
- Consider removing unwitnessed accidentally disconnected catheters.
- Catheters should not remain *in situ* longer than clinically necessary.

Diagnosis of Infectious Complications Associated with Neuraxial Techniques

- Perform daily evaluation of patients with indwelling catheters for early signs and symptoms (*e.g.,* fever, backache, headache, erythema, and tenderness at the insertion site) of infectious complications throughout their stay in the facility.§
- To minimize the impact of an infectious complication, promptly attend to signs or symptoms.
- If an infection is suspected:
  - Remove an *in situ* catheter and consider culturing the catheter tip.
  - Order appropriate blood tests.
  - Obtain appropriate cultures.
  - If an abscess is suspected or neurologic dysfunction is present, perform imaging studies and promptly obtain consultation with other appropriate specialties.

Management of Infectious Complications

- Administer appropriate antibiotic therapy at the earliest sign or symptom of a serious neuraxial infection.
- Consider consultation with a physician with expertise in the diagnosis and treatment of infectious diseases.
- If an abscess is present, obtain surgical consultation to determine whether percutaneous drainage of the abscess or surgery (*e.g.,* laminectomy) is warranted.

‡ Consult product labels for instructions regarding the proper use, application, and drying time for skin antiseptics.

§ Immunocompromised patients may not manifest typical signs and symptoms of infection.

Appendix 2: Methods and Analyses

For this updated Advisory, a systematic review of studies used in the development of the original Advisory was combined with a systematic review of studies published subsequent to ASA approval in 2010. Both the systematic literature review and opinion data are based on *evidence linkages*, or statements regarding potential relationships between prevention, diagnosis, or management interventions and infectious complications.* Interventions listed in the evidence model below were examined to assess their impact on outcomes related to infectious complications associated with neuraxial techniques.

Evidence Model

Patients

Inclusion criteria:

- Patients receiving neuraxial techniques
- Patients at increased risk of infectious complications
- Hospital inpatients (*e.g.*, operating rooms, intensive care units, postoperative surgical floors, labor and delivery settings, hospital wards)
- Patients in ambulatory care facilities (*e.g.*, pain clinics)

Exclusion criteria:

- Patients with implantable drug delivery systems
- Patients with chronic indwelling neuraxial analgesic delivery systems

Procedures

Inclusion criteria:

- Inpatient and ambulatory procedures requiring neuraxial administration
  - Epidural techniques
  - Spinal techniques
  - Combined spinal-epidural techniques
  - Lumbar puncture or spinal tap
  - Epidural blood patch
  - Epidural lysis of adhesions
  - Spinal injection of contrast agents for imaging
  - Lumbar or spinal drainage catheters
  - Spinal cord stimulation trials
- Neuraxial drugs
  - Anesthetics
  - Analgesics
  - Steroids
  - Intrathecal chemotherapy

* Unless otherwise specified, outcomes for the listed interventions refer to the occurrence of infectious complications.

Exclusion criteria:
- Injection techniques outside the neuraxis (*e.g.*, peripheral nerve blocks, joint and bursal injections)

Interventions

Identification of patients at increased risk of infectious complications (*e.g.*, coexisting infections, diabetes, cancer, arthritis, trauma):

- Medical records review (focused history)
- Physical examination
- Preprocedure laboratory evaluation

Prevention of infectious complications:
- Prophylactic antibiotic therapy (*vs.* no antibiotic therapy) in the known or suspected bacteremic or immunocompromised patient
  - Occlusive dressings
  - Individual packets *versus* multiple-use bottles of antiseptic
  - Aseptic preparation

Physician aseptic techniques during neuraxial procedures (*e.g.*, hand washing, sterile gowns, gloves, and drapes, wearing of caps and masks):
- Chlorhexidine (Hibiclens) *versus* Povidone iodine (Betadine)
- Aseptic preparation with *versus* without alcohol

Neuraxial techniques:
- Epidural *versus* spinal techniques
- Continuous infusion epidural *versus* single injection epidural
- Lumbar epidural *versus* thoracic epidural techniques
- Lumbar *versus* caudal techniques

Neuraxial delivery:
- Long duration of catheterization (trend data or > 5 days duration of catheterization)
- Limit disconnection and reconnection of neuraxial delivery systems
- Remove an accidentally disconnected catheter
- Use a filter during continuous epidural infusion

Diagnosis of infectious complications:
- Patient monitoring
- Periodically checking for signs/symptoms of infection (erythema, tenderness, fever)
- Periodically checking neurologic function

Diagnostic testing:
- Blood tests (*e.g.,* white blood count, sedimentation rate, C-reactive protein)
- Culture or cerebrospinal fluid analysis
- Imaging (computed tomography, magnetic resonance imaging)

Management of infectious complications:
- Antibiotic therapy
- Percutaneous drainage of abscess
- Surgery
  - Surgery with antibiotic therapy
  - Surgery without antibiotic therapy

Outcomes

Expected benefits:
- Prevention and management of infectious complications
  - Epidural, spinal or subdural abscess
  - Paravertebral, paraspinous, or psoas abscess
  - Meningitis
  - Encephalitis
  - Sepsis
  - Bacteremia
  - Viremia
  - Fungemia
  - Osteomyelitis
  - Discitis
  - Catheter colonization (precursor to infection)

Evidence Collection

Inclusion criteria:
- RCTs
- Prospective nonrandomized comparative studies (*e.g.,* quasi-experimental, cohort)
- Retrospective comparative studies (*e.g.,* case-control)
- Observational (*e.g.,* correlational or descriptive statistics)
- Case reports, case series

Exclusion criteria:
- Editorials
- Literature reviews
- Meta-analyses
- Abstracts greater than 5 yr old
- Unpublished studies
- Studies in non-peer-reviewed journals
- Newspaper articles

Survey evidence:
- Expert consultant survey
- ASA membership survey
- Literature reliability survey
- Feasibility of implementation survey

State of the Literature. For the systematic literature review, potentially relevant clinical studies were identified *via* electronic and manual searches of the literature. Health care database searches included PubMed, Web of Science, Google Books, and the Cochrane Central Register of Controlled Trials. The updated searches covered a 6.25-yr period from January 1, 2010, through March 31, 2016. New citations were reviewed and combined with pre-2010 articles used in the previous update, resulting in a total of 524 articles reviewed; 220 were found to contain direct linkage-related evidence. Search terms consisted of the interventions indicated above guided by the appropriate inclusion/exclusion criteria as stated in the "Focus" section of this Advisory. Only studies containing original findings

from peer-reviewed journals are acceptable. Editorials, letters, and other articles without data are excluded. A complete bibliography used to develop this updated Advisory, organized by section, is available as Supplemental Digital Content 2, http://links.lww.com/ALN/B371.

Each pertinent outcome reported in a study was classified by evidence category and level and designated as beneficial, harmful, or equivocal. Findings were then summarized for each evidence linkage and reported in the text of the updated Advisory.

For the original Advisory, interobserver agreement among Task Force members and two methodologists was established by interrater reliability testing. Agreement levels using a κ statistic for two-rater agreement pairs were as follows: (1) type of study design, κ = 0.79 to 0.92; (2) type of analysis, κ = 0.84 to 1.00; (3) evidence linkage assignment, κ = 0.81 to 1.00; and (4) literature inclusion for database, κ = 0.75 to 1.00. Three-rater chance-corrected agreement values were: (1) study design, Sav = 0.965, Var (Sav) = 0.001; (2) type of analysis, Sav = 0.961, Var (Sav) = 0.001; (3) linkage assignment, Sav = 0.637, Var (Sav) = 0.025; (4) literature database inclusion, Sav = 0.824, Var (Sav) = 0.019. These values represent moderate to high levels of agreement.

Consensus-based Evidence. For the original Advisory, consensus was obtained from multiple sources, including: (1) survey opinions from consultants who were selected based on their knowledge or expertise in neuraxial techniques, (2) survey opinions solicited from active members of the ASA, (3) testimony from attendees of publicly-held open forums at four national anesthesia meetings, (4) Internet commentary, and (5) Task Force opinion and interpretation. The survey rate of return was 39% (n = 46 of 119) for the consultants, and 239 surveys were received from active ASA members. Results of the surveys are reported in tables 1 and 2, and summarized in the text of this updated Advisory.

The consultants were asked to indicate which, if any, of the evidence linkages would change their clinical practices if the Advisory was instituted. The rate of return was 14% (n = 17 of 119). The percent of responding consultants expecting a change in their practice associated with each linkage topic was as follows: (1) history and physical examination = 5.9%; (2) use and selection of neuraxial techniques = 5.9%, aseptic techniques = 41.2%; (3) disconnection and reconnection of catheters = 23.5%; (4) duration of catheterization = 6.9%; (5) checking for signs and symptoms of an infectious complication = 5.9%; (6) use of antibiotics = 5.9%; and (7) consultation with other specialists = 5.9%. Eighty-eight percent of the respondents indicated that the Advisory would have *no effect* on the amount of time spent on a typical case, and 11.8% indicated an average increase of 2.8 min in the amount of time expected to spend on a typical case with the implementation of this Advisory. Eighty-two percent indicated that new equipment, supplies, or training would *not* be needed in order to implement the guidelines, and 76.4% indicated that implementation of the Advisory would *not* require changes in practice that would affect costs.

Table 1. Consultant Survey Responses

		Percent Responding to Each Item				
	N*	Strongly Agree	Agree	Equivocal	Disagree	Strongly Disagree
I. Prevention of Infectious Complications:						
A history, physical examination, and review of relevant laboratory studies should be conducted prior to performing neuraxial techniques	46	73.9*	23.9	2.2	0.0	0.0
A history, physical examination, and review of relevant laboratory studies is useful in identifying patients at increased risk of infectious complications prior to performing neuraxial techniques	46	33.6	58.7*	8.7	0.0	0.0
***For patients determined to be at risk of infectious complications*:**						
The decision to select a neuraxial technique should be determined on a case-by-case basis	46	73.9*	23.9	2.2	0.0	0.0
Alternatives to neuraxial techniques should be considered	46	47.8	47.8*	4.4	0.0	0.0
Consider the evolving medical status of the patient in selection of a neuraxial technique	46	65.2*	34.8	0.0	0.0	0.0
When a neuraxial technique is selected in a known or suspected bacteremic patient, preprocedure antibiotic therapy should be administered	45	60.0*	26.7	13.3	0.0	0.0
Lumbar puncture should be avoided in a patient with a known epidural abscess	46	56.5*	23.9	17.4	2.2	0.0
***Aseptic techniques*:**						
Aseptic techniques should always be used during the placement of neuraxial needles and catheters	46	93.5*	6.5	0.0	0.0	0.0

(*Continued*)

Table 1. (Continued)

	N*	Percent Responding to Each Item: Strongly Agree	Agree	Equivocal	Disagree	Strongly Disagree
Aseptic techniques should include:						
Removal of jewelry	46	30.4	41.3*	15.2	13.0	0.0
Hand washing	46	76.1*	17.4	2.2	4.4	0.0
Wearing of sterile gloves	46	100.0*	0.0	0.0	0.0	0.0
Wearing of caps	45	64.4*	22.2	4.4	6.7	2.2
Wearing of gowns	46	19.6	13.0	21.7*	28.3	17.4
Wearing of masks covering both mouth and nose	46	80.4*	10.9	2.2	6.5	0.0
Changing masks before each new case	46	28.3	30.4*	23.9	10.9	6.5
Use of individual packets for skin preparation	46	50.0*	28.3	8.7	8.7	4.4
Sterile draping of the patient	46	78.3*	15.2	2.2	4.4	0.0
Use of sterile occlusive dressing at the catheter insertion site	46	60.9*	17.4	13.0	8.7	0.0
Which skin preparation solution do you prefer prior to performing a neuraxial technique? (mean rank)†						
Chlorhexidine (2.40)						
Chlorhexidine with alcohol (1.65)						
Povidone-iodine (3.21)						
Povidone-iodine with alcohol (2.57)						
Other (4.96)						
Bacterial filters should be used during continuous epidural infusion	46	26.1	17.4	26.1*	21.7	8.7
Limit the disconnection and reconnection of neuraxial delivery systems in order to minimize the risk of infectious complications	46	50.0*	37.0	10.9	2.2	0.0
Immediately remove accidentally disconnected catheters	46	4.4	13.0	32.6	43.5*	6.5
Catheters should not remain *in situ* longer than clinically necessary	46	56.5*	34.8	6.5	0.0	2.2
II. Diagnosis of Infectious Complications:						
Periodic evaluation of patients for signs and symptoms (*e.g.*, fever, backache, headache, erythema, and tenderness at the insertion site) is essential for the early identification of infectious complications	46	52.2*	37.0	6.5	4.4	0.0
Following neuraxial insertion or catheter insertion, how frequently should signs and symptoms be assessed? (percentage response)	45					
More than twice a day (2.2)						
Twice a day (37.8)						
Once a day (57.8*)						
Once every other day (0.0)						
Less than once every other day (2.2)						
Signs or symptoms should be promptly attended to in order to minimize the impact of an infectious complication	46	71.7*	28.3	0.0	0.0	0.0
If an infection is suspected: An *in situ* catheter should be immediately removed	46	67.4*	21.7	6.5	2.2	2.2
The catheter tip should be cultured	46	54.4*	30.4	4.4	4.4	6.5
Blood tests should be ordered	46	34.8	47.8*	8.7	6.5	2.2
Additional cultures should be obtained	45	21.7	30.4*	37.0	8.7	2.2
If an abscess is suspected or neurologic deficit is present, imaging studies should be performed	45	91.1*	8.9	0.0	0.0	0.0
If an abscess is suspected or neurologic deficit is present, consultation with other appropriate specialties should be promptly obtained	46	95.7*	2.2	2.2	0.0	0.0
III. Management of Infectious Complications:						
Appropriate antibiotic therapy should *always* be administered at the earliest sign or symptom of a serious infection	46	50.0*	30.4	8.7	8.7	2.2
A specialist or physician with expertise in the diagnosis and treatment of infectious diseases should be consulted at the first sign of a serious infection	46	37.0	43.5*	10.9	8.7	0.0
If an abscess is present, surgical consultation should be obtained to determine whether percutaneous drainage of the abscess or surgery (*e.g.*, laminectomy) is warranted	46	78.3*	21.7	0.0	0.0	0.0

*N = the number of consultants who responded to each item. An asterisk beside a percentage score indicates the median.

†Respondents were asked to rank solutions from 1 (most preferred) to 5 (least preferred). Mean rank reported.

Table 2. American Society of Anesthesiologists (ASA) Membership Survey Responses

	Percent Responding to Each Item					
	N*	Strongly Agree	Agree	Equivocal	Disagree	Strongly Disagree
I. Prevention of Infectious Complications:						
A history, physical examination, and review of relevant laboratory studies should be conducted prior to performing neuraxial techniques	238	74.0*	23.1	2.2	0.4	0.4
A history, physical examination, and review of relevant laboratory studies is useful in identifying patients at increased risk of infectious complications prior to performing neuraxial techniques	238	50.0*	37.0	10.9	1.7	0.4
***For patients determined to be at risk of infectious complications*:**						
The decision to select a neuraxial technique should be determined on a case-by-case basis	238	68.1*	30.3	0.4	0.4	0.8
Alternatives to neuraxial techniques should be considered	237	55.7*	40.1	2.5	1.3	0.4
Consider the evolving medical status of the patient in selection of a neuraxial technique	238	63.5*	35.3	1.3	0.0	0.0
When a neuraxial technique is selected in a known or suspected bacteremic patient, preprocedure antibiotic therapy should be administered	236	59.3*	22.0	17.4	0.4	0.9
Lumbar puncture should be avoided in a patient with a known epidural abscess	238	78.2*	16.8	5.0	0.0	0.0
***Aseptic techniques*:**						
Aseptic techniques should always be used during the placement of neuraxial needles and catheters	238	91.2*	8.8	0.0	0.0	0.0
Aseptic techniques should include:						
Removal of jewelry	235	30.2	23.0*	27.2	17.0	2.6
Hand washing	237	69.6*	21.1	7.6	1.3	0.4
Wearing of sterile gloves	239	94.6*	3.8	0.8	0.4	0.4
Wearing of caps	236	57.2*	21.6	14.4	5.5	1.3
Wearing of gowns	233	11.2	9.0	34.8*	39.5	5.6
Wearing of masks covering both mouth and nose	233	58.4*	24.9	9.0	7.7	0.0
Changing masks before each new case	232	18.5	21.1	29.7*	25.4	5.2
Use of individual packets for skin preparation	235	59.2*	30.6	8.5	1.3	0.4
Sterile draping of the patient	237	60.8*	22.8	6.8	8.9	0.8
Use of sterile occlusive dressing at the catheter insertion site	239	54.4*	29.3	11.7	3.8	0.8
Which skin preparation solution do you prefer prior to performing a neuraxial technique? (mean rank)†						
Chlorhexidine (2.45)						
Chlorhexidine with alcohol (2.45)						
Povidone-iodine (2.28)						
Povidone-iodine with alcohol (2.62)						
Other (4.86)						
Bacterial filters should be used during continuous epidural infusion	236	23.7	29.7*	30.5	14.4	1.7
Limit the disconnection and reconnection of neuraxial delivery systems in order to minimize the risk of infectious complications	238	52.9*	39.9	6.7	0.4	0.0
Immediately remove accidentally disconnected catheters	237	13.9	23.2	36.3*	24.9	1.7
Catheters should not remain *in situ* longer than clinically necessary	238	65.6*	32.4	2.1	0.0	0.0
II. Diagnosis of Infectious Complications:						
Periodic evaluation of patients for signs and symptoms (*e.g.*, fever, backache, headache, erythema, and tenderness at the insertion site) is essential for the early identification of infectious complications	237	54.4*	40.9	4.6	0.0	0.0

(*Continued*)

Table 2. (Continued)

	Percent Responding to Each Item					
	N*	Strongly Agree	Agree	Equivocal	Disagree	Strongly Disagree
Following neuraxial insertion or catheter insertion, how frequently should signs and symptoms be assessed? (percentage response)	236					
More than twice a day (13.1)						
Twice a day (29.7)						
Once a day (55.1*)						
Once every other day (0.4)						
Less than once every other day (1.7)						
Signs or symptoms should be promptly attended to in order to minimize the impact of an infectious complication	237	76.8*	21.5	1.7	0.0	0.0
If an infection is suspected:						
An *in situ* catheter should be immediately removed	235	75.3*	22.1	2.6	0.0	0.0
The catheter tip should be cultured	235	60.9*	26.4	11.5	0.9	0.9
Blood tests should be ordered	237	43.9	28.9*	23.6	3.4	0.4
Additional cultures should be obtained	232	30.6	28.0*	37.9	3.0	0.4
If an abscess is suspected or neurologic deficit is present, imaging studies should be performed	233	83.3*	14.6	1.7	0.4	0.0
If an abscess is suspected or neurologic deficit is present, consultation with other appropriate specialties should be promptly obtained	234	94.4*	5.6	0.0	0.0	0.0
III. Management of Infectious Complications:						
Appropriate antibiotic therapy should *always* be administered at the earliest sign or symptom of a serious infection	236	61.9*	21.6	13.1	3.0	0.4
A specialist or physician with expertise in the diagnosis and treatment of infectious diseases should be consulted at the first sign of a serious infection	238	58.4*	26.5	11.3	3.8	0.0
If an abscess is present, surgical consultation should be obtained to determine whether percutaneous drainage of the abscess or surgery (*e.g.*, laminectomy) is warranted	238	81.1*	16.4	2.1	0.4	0.0

*N = the number of ASA members who responded to each item. An asterisk beside a percentage score indicates the median.

†Respondents were asked to rank solutions from 1 (most preferred) to 5 (least preferred). Mean rank reported.

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Competing Interests

The authors declare no competing interests.

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References

1. Bomberg H, Kubulus C, List F, Albert N, Schmitt K, Gräber S, Kessler P, Steinfeldt T, Standl T, Gottschalk A, Wirtz SP, Burgard G, Geiger P, Spies CD, Volk T; German Network for Regional Anaesthesia Investigators: Diabetes: a risk factor for catheter-associated infections. Reg Anesth Pain Med 2015; 40:16–21
2. Erdine S, Aldemir T: Long-term results of peridural morphine in 225 patients. Pain 1991; 45:155–9
3. Gritsenko K, Marcello D, Liguori GA, Jules-Elysée K, Memtsoudis SG: Meningitis or epidural abscesses after neuraxial block for removal of infected hip or knee prostheses. Br J Anaesth 2012; 108:485–90
4. Jakobsen KB, Christensen MK, Carlsson PS: Extradural anaesthesia for repeated surgical treatment in the presence of infection. Br J Anaesth 1995; 75:536–40
5. Moen V, Dahlgren N, Irestedt L: Severe neurological complications after central neuraxial blockades in Sweden 1990-1999. Anesthesiology 2004; 101:950–9
6. Pegues DA, Carr DB, Hopkins CC: Infectious complications associated with temporary epidural catheters. Clin Infect Dis 1994; 19:970–2
7. Rygnestad T, Borchgrevink PC, Eide E: Postoperative epidural infusion of morphine and bupivacaine is safe on surgical wards. Organisation of the treatment, effects and side-effects in 2000 consecutive patients. Acta Anaesthesiol Scand 1997; 41:868–76
8. Smitt PS, Tsafka A, Teng-van de Zande F, van der Holt R, Elswijk-de Vries I, Elfrink E, van den Bent MJ, Vecht CJ: Outcome and complications of epidural analgesia in patients with chronic cancer pain. Cancer 1998; 83:2015–22
9. Sillevis Smitt P, Tsafka A, van den Bent M, de Bruin H, Hendriks W, Vecht C, Teng-van de Zande F: Spinal epidural abscess complicating chronic epidural analgesia in 11 cancer patients: clinical findings and magnetic resonance imaging. J Neurol 1999; 246:815–20
10. Smith KM, Deddish RB, Ogata ES: Meningitis associated with serial lumbar punctures and post-hemorrhagic hydrocephalus. J Pediatr 1986; 109:1057–60
11. Van Dongen RT, Crul BJ, De Bock M: Long-term intrathecal infusion of morphine and morphine/bupivacaine mixtures in the treatment of cancer pain: a retrospective analysis of 51 cases. Pain 1993; 55:119–23

12. Beaudoin MG, Klein L: Epidural abscess following multiple spinal anaesthetics. Anaesth Intensive Care 1984; 12:163–4
13. Bengtsson M, Nettelblad H, Sjoberg F: Extradural catheter-related infections in patients with infected cutaneous wounds. Br J Anaesth 1997; 79:668–70
14. Brookman CA, Rutledge ML: Epidural abscess: case report and literature review. Reg Anesth Pain Med 2000; 25:428–31
15. Bülow PM, Biering-Sørensen F: Paraplegia, a severe complication to epidural analgesia. Acta Anaesthesiol Scand 1999; 43:233–5
16. Chevalier X, Lavabre C, Claudepierre P, Larget-Piet B: Iatrogenically induced vertebral osteomyelitis due to Pseudomonas aeruginosa. Clin Exp Rheumatol 1996; 14:191–4
17. Dawson P, Rosenfeld JV, Murphy MA, Hellyar AG: Epidural abscess associated with postoperative epidural analgesia. Anaesth Intensive Care 1991; 19:569–72
18. Eisen DP, MacGinley R, Christensson B, Larsson L, Woods ML: Candida tropicalis vertebral osteomyelitis complicating epidural catheterisation with disease paralleled by elevated D-arabinitol/L-arabinitol ratios. Eur J Clin Microbiol Infect Dis 2000; 19:61–3
19. Gosavi C, Bland D, Poddar R, Horst C: Epidural abscess complicating insertion of epidural catheters. Br J Anaesth 2004; 92:294; author reply 294–5
20. Heller AR, Ragaller M, Koch T: Epidural abscess after epidural catheter for pain release during pancreatitis. Acta Anaesthesiol Scand 2000; 44:1024–7
21. Hill JS, Hughes EW, Robertson PA: A Staphylococcus aureus paraspinal abscess associated with epidural analgesia in labour. Anaesthesia 2001; 56:873–8
22. Iseki M, Okuno S, Tanabe Y, Mitsuhata H, Miyazaki T: Methicillin-resistant Staphylococcus aureus sepsis resulting from infection in paravertebral muscle after continuous epidural infusion for pain control in a patient with herpes zoster. Anesth Analg 1998; 87:116–8
23. Knight JW, Cordingley JJ, Palazzo MG: Epidural abscess following epidural steroid and local anaesthetic injection. Anaesthesia 1997; 52:576–8
24. Kvalsvik O, Borchgrevink PC, Gisvold SE: Epidural abscess following continuous epidural analgesia in two traumatized patients. Acta Anaesthesiol Scand 1998; 42:732–5
25. Lin YC, Greco C: Epidural abscess following epidural analgesia in pediatric patients. Paediatr Anaesth 2005; 15:767–70
26. Mahendru V, Bacon DR, Lema MJ: Multiple epidural abscesses and spinal anesthesia in a diabetic patient. Case report. Reg Anesth 1994; 19:66–8
27. McDonogh AJ, Cranney BS: Delayed presentation of an epidural abscess. Anaesth Intensive Care 1984; 12:364–5
28. Nordström O, Sandin R: Delayed presentation of an extradural abscess in a patient with alcohol abuse. Br J Anaesth 1993; 70:368–9
29. Phillips JM, Stedeford JC, Hartsilver E, Roberts C: Epidural abscess complicating insertion of epidural catheters. Br J Anaesth 2002; 89:778–82
30. Sakuragi T, Yasunaka K, Hirata K, Hori K, Dan K: The source of epidural infection following epidural analgesia identified by pulsed-field gel electrophoresis. Anesthesiology 1998; 89:1254–6
31. Sarubbi FA, Vasquez JE: Spinal epidural abscess associated with the use of temporary epidural catheters: report of two cases and review. Clin Infect Dis 1997; 25:1155–8
32. Shioya N, Ishibe Y, Kan S, Masuda T, Matsumoto N, Takahashi G, Makabe H, Yamada Y, Endo S: Sternoclavicular joint septic arthritis following paraspinal muscle abscess and septic lumbar spondylodiscitis with epidural abscess in a patient with diabetes: a case report. BMC Emerg Med 2012; 12:7
33. Yap KB, Finlay IG: Epidural infection associated with epidural catheterization in a cancer patient with back pain: case report. Palliat Med 1994; 8:251–3
34. Zakaria M, Butt MU: Epidural abscess and meningitis, a complication of spinal anesthesia in a bacteraemic patient. J Pak Med Assoc 2009; 59:565–7
35. Raedler C, Lass-Flörl C, Pühringer F, Kolbitsch C, Lingnau W, Benzer A: Bacterial contamination of needles used for spinal and epidural anaesthesia. Br J Anaesth 1999; 83:657–8
36. Dawson SJ, Small H, Logan MN, Geringer S: Case control study of epidural catheter infections in a district general hospital. Commun Dis Public Health 2000; 3:300–2
37. Abouleish E, Orig T, Amortegui AJ: Bacteriologic comparison between epidural and caudal techniques. Anesthesiology 1980; 53:511–4
38. Kost-Byerly S, Tobin JR, Greenberg RS, Billett C, Zahurak M, Yaster M: Bacterial colonization and infection rate of continuous epidural catheters in children. Anesth Analg 1998; 86:712–6
39. McNeely JK, Trentadue NC, Rusy LM, Farber NE: Culture of bacteria from lumbar and caudal epidural catheters used for postoperative analgesia in children. Reg Anesth 1997; 22:428–31
40. Berman RS, Eisele JH: Bacteremia, spinal anesthesia, and development of meningitis. Anesthesiology 1978; 48:376–7
41. Videira RL, Ruiz-Neto PP, Brandao Neto M: Post spinal meningitis and asepsis. Acta Anaesthesiol Scand 2002; 46:639–46
42. Siddiqui NT, Davies S, McGeer A, Carvalho JC, Friedman Z: The effect of gowning on labor epidural catheter colonization rate: a randomized controlled trial. Reg Anesth Pain Med 2014; 39:520–4
43. Cohen S, Hunter CW, Sakr A, Hijazi RH: Meningitis following intrathecal catheter placement after accidental dural puncture. Int J Obstet Anesth 2006; 15:172
44. Couzigou C, Vuong TK, Botherel AH, Aggoune M, Astagneau P: Iatrogenic Streptococcus salivarius meningitis after spinal anaesthesia: need for strict application of standard precautions. J Hosp Infect 2003; 53:313–4
45. Pinder AJ, Dresner M: Meningococcal meningitis after combined spinal-epidural analgesia. Int J Obstet Anesth 2003; 12:183–7
46. Sandkovsky U, Mihu MR, Adeyeye A, De Forest PM, Nosanchuk JD: Iatrogenic meningitis in an obstetric patient after combined spinal-epidural analgesia: case report and review of the literature. South Med J 2009; 102:287–90
47. Shewmaker PL, Gertz RE Jr, Kim CY, de Fijter S, DiOrio M, Moore MR, Beall BW: Streptococcus salivarius meningitis case strain traced to oral flora of anesthesiologist. J Clin Microbiol 2010; 48:2589–91
48. Suy F, Verhoeven PO, Lucht F, Grattard F, Carricajo A, Pozzetto B, Berthelot P: Nosocomial meningitis due to Streptoccus salivarius linked to the oral flora of an anesthesiologist. Infect Control Hosp Epidemiol 2013; 34:331–2
49. Bevacqua BK, Slucky AV, Cleary WF: Is postoperative intrathecal catheter use associated with central nervous system infection? Anesthesiology 1994; 80:1234–40
50. Sellors J, Cyna A, Simmons S: Aseptic precautions for inserting and epidural catheter. Anaesthesia 2002; 57:593–605
51. Siddiqui NT, Anandakrishnan S, McGeer A, Guerina L, Carvalho J, Friedman Z: Hand washing technique for epidurals-effect on reduction of contamination risk. Can J Anesthesia 2012; 59:54
52. Yuan HB, Zuo Z, Yu KW, Lin WM, Lee HC, Chan KH: Bacterial colonization of epidural catheters used for short-term postoperative analgesia: microbiological examination and risk factor analysis. Anesthesiology 2008; 108:130–7
53. Abaza KT, Bogod DG: Cerebrospinal fluid-cutaneous fistula and pseudomonas meningitis complicating thoracic epidural analgesia. Br J Anaesth 2004; 92:429–31
54. Bajwa ZH, Ho C, Grush A, Kleefield J, Warfield CA: Discitis associated with pregnancy and spinal anesthesia. Anesth Analg 2002; 94:415–6, table of contents

55. Barnwell R, Ball V: Iatrogenic bacterial meningitis: an unmasked threat. CJEM 2012; 14:259–62
56. Blackmore TK, Morley HR, Gordon DL: Streptococcus mitis-induced bacteremia and meningitis after spinal anesthesia. Anesthesiology 1993; 78:592–4
57. Bouhemad B, Dounas M, Mercier FJ, Benhamou D: Bacterial meningitis following combined spinal-epidural analgesia for labour. Anaesthesia 1998; 53:292–5
58. Cascio M, Heath G: Meningitis following a combined spinal-epidural technique in a labouring term parturient. Can J Anaesth 1996; 43:399–402
59. Chiang HL, Chia YY, Chen YS, Hung CC, Liu K, Lo Y: Epidural abscess in an obstetric patient with patient-controlled epidural analgesia–a case report. Int J Obstet Anesth 2005; 14:242–5
60. Collis RE, Harries SE: A subdural abscess and infected blood patch complicating regional analgesia for labour. Int J Obstet Anesth 2005; 14:246–51
61. Emmanuel ER: Post-sacral extradural catheter abscess in a child. Br J Anaesth 1994; 73:548–9
62. Hernández-Palazón J, Puertas-García JP, Martínez-Lage JF, Tortosa JA: Lumbar spondylodiscitis caused by Propionibacterium acnes after epidural obstetric analgesia. Anesth Analg 2003; 96:1486–8, table of contents
63. Huang YY, Zuo Z, Yuan HB, Tsou MY, Chen MT, Tsai SK: A paraspinal abscess following spinal anaesthesia for caesarean section and patient-controlled epidural analgesia for postoperative pain. Int J Obstet Anesth 2005; 14:252–5
64. Ingelmo PM, Marino G, Fumagalli R: Sepsis after epidural catheterization in a child with chronic regional pain syndrome type I. Paediatr Anaesth 2005; 15:623–4
65. Jeffreys A, Horton R, Evans B: Epidural abscesses. Br J Anaesth 2006; 97:115–6
66. Laurila JJ, Kostamovaara PA, Alahuhta S: Streptococcus salivarius meningitis after spinal anesthesia. Anesthesiology 1998; 89:1579–80
67. Meunier JF, Norwood P, Dartayet B, Dubousset AM, Ecoffey C: Skin abscess with lumbar epidural catheterization in infants: is it dangerous? Report of two cases. Anesth Analg 1997; 84:1248–9
68. Newton JA, Lesnik IK, Kennedt CA: Streptococcus salivarius meningitis following spinal anesthesia. Clin Infect Dis 1994; 18:840–1
69. Ready LB, Helfer D: Bacterial meningitis in parturients after epidural anesthesia. Anesthesiology 1989; 71:988–90
70. Schroeder TH, Krueger WA, Neeser E, Hahn U, Unertl K: Spinal epidural abscess–a rare complication after epidural analgesia for labour and delivery. Br J Anaesth 2004; 92:896–8
71. Schröter J, Wa Djamba D, Hoffmann V, Bach A, Motsch J: Epidural abscess after combined spinal-epidural block. Can J Anaesth 1997; 44:300–4
72. Stallard N, Barry P: Another complication of the combined extradural-subarachnoid technique. Br J Anaesth 1995; 75:370–1
73. Villevielle T, Vincent-Rouquette I, Petitjeans F, Koulmann P, Legulluche Y, Rousseau JM, Diraison Y, Brinquin: Strepoccus miitis-induced meningitis after spinal anesthesia. Anesth Analg 2000; 90:500–1
74. Yentur A, Topcu I, Isik R, Degerli K, Surucuoglu S: Underestimated role of alcohol at skin disinfection: lipid dissolving property when used in association with conventional antiseptic agents. Turkish J Med Sci 2010; 40:593–8
75. Kasuda H, Fukuda H, Togashi H, Hotta K, Hirai Y, Hayashi M: Skin disinfection before epidural catheterization: comparative study of povidone-iodine *versus* chlorhexidine ethanol. Dermatology 2002; 204 Suppl 1:42–6
76. Kinirons B, Mimoz O, Lafendi L, Naas T, Meunier J, Nordmann P: Chlorhexidine *versus* povidone iodine in preventing colonization of continuous epidural catheters in children: a randomized, controlled trial. Anesthesiology 2001; 94:239–44
77. Krobbuaban B, Diregpoke S, Prasan S, Thanomsat M, Kumkeaw S: Alcohol-based chlorhexidine vs. povidone iodine in reducing skin colonization prior to regional anesthesia procedures. J Med Assoc Thai 2011; 94:807–12
78. Nahm FS, Ahn W, Lee CJ, Ham BM: Chlorhexidine versus povidone iodine in bacterial contamination rate of needles used for spinal anesthesia. Korean J Anesthesiol 2004; 47:S1–S4
79. Birnbach DJ, Stein DJ, Murray O, Thys DM, Sordillo EM: Povidone iodine and skin disinfection before initiation of epidural anesthesia. Anesthesiology 1998; 88:668–72
80. Hernández-Palazón J, Puertas-García JP, Martínez-Lage JF, Tortosa JA: Lumbar spondylodiscitis caused by Propionibacterium acnes after epidural obstetric analgesia. Anesth Analg 2003; 96:1486–8, table of contents
81. Seth N, Macqueen S, Howard RF: Clinical signs of infection during continuous postoperative epidural analgesia in children: the value of catheter tip culture. Paediatr Anaesth 2004; 14:996–1000
82. Trojanowski A, Janicki P: Bacterial contamination of epidural catheters used for perioperative analgesia. Internet J Anesthesiol 2008; 20: http://print.ispub.com/api/0/ispub-article/3469
83. Dhillon AR, Russell IF: Epidural abscess in association with obstetric epidural analgesia. Int J Obstet Anesth 1997; 6:118–21
84. Simons R, Dinner L, Lappin S: Skin abscess obscured by epidural catheter fixation. Anaesthesia 2007; 62:418
85. Abouleish E, Amortegui AJ, Taylor FH: Are bacterial filters needed in continuous epidural analgesia for obstetrics? Anesthesiology 1977; 46:351–4
86. James FM, George RH, Naiem H, White GJ: Bacteriologic aspects of epidural analgesia. Anesth Analg 1976; 55:187–90
87. Borum SE, McLeskey CH, Williamson JB, Harris FS, Knight AB: Epidural abscess after obstetric epidural analgesia. Anesthesiology 1995; 82:1523–6
88. Evans PR, Misra U: Poor outcome following epidural abscess complicating epidural analgesia for labour. Eur J Obstet Gynecol Reprod Biol 2003; 109:102–5
89. Kindler C, Seeberger M, Siegemund M, Schneider M: Extradural abscess complicating lumbar extradural anaesthesia and analgesia in an obstetric patient. Acta Anaesthesiol Scand 1996; 40:858–61
90. Tay SM, Lee R: Case report: catheter-related epidural abscess. Ann Acad Med Singapore 2001; 30:62–5
91. Allen S, Kalsi A, Shankar S, Jones N: Rate of bacterial colonisation and infective complications of epidurals in situ for prolonged duration in patients undergoing laparotomy for pseudomyxoma peritonei. Anaesthesia 2014; 69(suppl 4):43
92. de Jong PC, Kansen PJ: A comparison of epidural catheters with or without subcutaneous injections ports for treatment of cancer pain. Anesth Analg 1994; 78:94–100
93. de Leon-Casasola OA, Parker B, Lema MJ, Harrison P, Massey J: Postoperative epidural bupivacaine-morphine therapy. Experience with 4,227 surgical cancer patients. Anesthesiology 1994; 81:368–75
94. Holt HM, Andersen SS, Andersen O, Gahrn-Hansen B, Siboni K: Infections following epidural catheterization. J Hosp Infect 1995; 30:253–60
95. Mann TJ, Orlikowski CE, Gurrin LC, Keil AD: The effect of the biopatch, a chlorhexidine impregnated dressing, on bacterial colonization of epidural catheter exit sites. Anaesth Intensive Care 2001; 29:600–3
96. Mishra S, Bhatnagar S, Srikanti M, Gupta D: Clinical implication of routine bacterial culture from epidural catheter tips in postoperative cancer patients: a prospective study. Anaesthesia 2006; 61:878–82

97. Srivastava U CP, Saxena S, Kumar A, Kannaujia A, Singh Rana SP, Issar H: Bacterial colonization and infection of epidural catheters: a prospective study of incidence and risk factors in surgical patients. Indian J Anaesth 2007; 51:496–500
98. Wang LP, Hauerberg J, Schmidt JF: Incidence of spinal epidural abscess after epidural analgesia: a national 1-year survey. Anesthesiology 1999; 91:1928–36
99. Hernandez JM, Coyle FP, Wright CD, Ballantyne JC: Epidural abscess after epidural anesthesia and continuous epidural analgesia in a patient with gastric lymphoma. J Clin Anesth 2003; 15:48–51
100. Hori K, Kano T, Fukushige T, Sano T: Successful treatment of epidural abscess with a percutaneously introduced 4-French catheter for drainage. Anesth Analg 1997; 84:1384–6
101. Larsson BA, Lundeberg S, Olsson GL: Epidural abscess in a one-year-old boy after continuous epidural analgesia. Anesth Analg 1997; 84:1245–7
102. Nordberg G, Mark H: Epidural abscess after epidural analgesia treated successfully with antibiotics. Acta Anaesthesiol Scand 1998; 42:727–31
103. Tham EJ, Stoodley MA, Macintyre PE, Jones NR: Back pain following postoperative epidural analgesia: an indicator of possible spinal infection. Anaesth Intensive Care 1997; 25:297–301
104. Aldrete JA, Williams SK: Infections from extended epidural catheterization in ambulatory patients. Reg Anesth Pain Med 1998; 23:491–5
105. Christie IW, McCabe S: Major complications of epidural analgesia after surgery: results of a six-year survey. Anaesthesia 2007; 62:335–41
106. Darchy B, Forceville X, Bavoux E, Soriot F, Domart Y: Clinical and bacteriologic survey of epidural analgesia in patients in the intensive care unit. Anesthesiology 1996; 85:988–98
107. Aram L, Krane EJ, Kozloski LJ, Yaster M: Tunneled epidural catheters for prolonged analgesia in pediatric patients. Anesth Analg 2001; 92:1432–8
108. Athmaja TR, Sanders GM: An unusual presentation of epidural Acinetobacter infection. Reg Anesth Pain Med 2005; 30:577–9
109. Baer ET: Post-dural puncture bacterial meningitis. Anesthesiology 2006; 105:381–93
110. Bertol V, Ara JR, Oliveros A, Gros B: Neurologic complications of lumbar epidural analgesia: spinal and paraspinal abscess. Neurology 1997; 48:1732–3
111. Brooks K, Pasero C, Hubbard L, Coghlan RH: The risk of infection associated with epidural analgesia. Infect Control Hosp Epidemiol 1995; 16:725–8
112. Bussink M, Gramke HF, Van Kleef M, Marcus M: Bacterial meningitis ten days after spinal anesthesia. Reg Anesth Pain Med 2005; 30:210–1
113. Cesari M, Onder G, Torre S, Landi F, Carbonin P, Gambassi G: A "painful" epidural analgesia. J Am Geriatr Soc 2004; 52:329–30
114. Choy JC: Mortality from peripartum meningitis. Anaesth Intensive Care 2000; 28:328–30
115. Coapes CM, Roysam GS: Vertebral osteomyelitis secondary to epidural catheter use: a case report. Spine (Phila Pa 1976) 2001; 26:1492–4
116. Collier CB, Gatt SP: Epidural abscess in an obstetric patient. Anaesth Intensive Care 1999; 27:662–6
117. Cooper AB, Sharpe MD: Bacterial meningitis and cauda equina syndrome after epidural steroid injections. Can J Anaesth 1996; 43(5 Pt 1):471–4
118. Cummings KC 3rd, Dolak JA: Case report: epidural abscess in a parturient with pruritic urticarial papules and plaques of pregnancy (PUPPP). Can J Anaesth 2006; 53:1010–4
119. Dysart RH, Balakrishnan V: Conservative management of extradural abscess complicating spinal-extradural anaesthesia for caesarean section. Br J Anaesth 1997; 78:591–3
120. Edelstein S, Edoute Y: Bacterial sacroiliitis probably induced by lumbar epidural analgesia. Infect Dis Obstet Gynecol 2003; 11:105–8
121. Hearn M: Epidural abscess complicating insertion of epidural catheters. Br J Anaesth 2003; 90:706–7; author reply 707
122. Hooten WM, Kinney MO, Huntoon MA: Epidural abscess and meningitis after epidural corticosteroid injection. Mayo Clin Proc 2004; 79:682–6
123. Huang RC, Shapiro GS, Lim M, Sandhu HS, Lutz GE, Herzog RJ: Cervical epidural abscess after epidural steroid injection. Spine (Phila Pa 1976) 2004; 29:E7–9
124. Idigoras P, Valiente A, Iglesias L, Trieu-Cout P, Poyart C: Meningitis due to Streptococcus salivarius. J Clin Microbiol 2001; 39:3017
125. Kocamanoglu IS, Sener EB, Tür A, Ustün E, Sahinoglu H: Streptococcal meningitis after spinal anesthesia: report of a case. Can J Anaesth 2003; 50:314–5
126. Koka VK, Potti A: Spinal epidural abscess after corticosteroid injections. South Med J 2002; 95:772–4
127. Kruger M, Harries K, Dumont S: Osteomyelitis following epidural analgesia in an immunocompromised patient. Anaesthesia 1998; 53:314–5
128. Lehman RA Jr, Lenke LG: Extensive epidural abscess treated with a thoracic laminoplasty. Spine J 2011; 11:798–9
129. Lindner A, Warmuth-Metz M, Becker G, Toyka VV: Iatrogenic spinal epidural abscesses: early diagnosis essential for good outcome. Eur J Med Res 1997; 2:201–5
130. Liu SS, Pope A: Spinal meningitis masquerading as postdural puncture headache. Anesthesiology 1996; 85:1493–4
131. Lurie S, Feinstein M, Heifetz C, Mamet Y: Iatrogenic bacterial meningitis after spinal anesthesia for pain relief during labor. J Clin Anesth 1999; 11:438–9
132. Raj V, Foy J: Paraspinal abscess associated with epidural in labour. Anaesth Intensive Care 1998; 26:424–6
133. Rathmell JP, Garahan MB, Alsofrom GF: Epidural abscess following epidural analgesia. Reg Anesth Pain Med 2000; 25:79–82
134. Royakkers AA, Willigers H, van der Ven AJ, Wilmink J, Durieux M, van Kleef M: Catheter-related epidural abscesses – don't wait for neurological deficits. Acta Anaesthesiol Scand 2002; 46:611–5
135. Rubin L, Sprecher H, Kabaha A, Weber G, Teitler N, Rishpon S: Meningitis following spinal anesthesia: 6 cases in 5 years. Infect Control Hosp Epidemiol 2007; 28:1187–90
136. Schneeberger PM, Janssen M, Voss A: Alpha-hemolytic streptococci: a major pathogen of iatrogenic meningitis following lumbar puncture. Case reports and a review of the literature. Infection 1996; 24:29–33
137. Siman-Tov T, Gadoth N: Enterococcal meningoencephalitis following epidural anesthesia. Isr Med Assoc J 2004; 6:780–1
138. Thomas TA, Cooper GM; Editorial Board of the Confidential Enquiries into Maternal Deaths in the United Kingdom: Maternal deaths from anaesthesia. An extract from Why mothers die 1997-1999, the Confidential Enquiries into Maternal Deaths in the United Kingdom. Br J Anaesth 2002; 89:499–508
139. Trautmann M, Lepper PM, Schmitz FJ: Three cases of bacterial meningitis after spinal and epidural anesthesia. Eur J Clin Microbiol Infect Dis 2002; 21:43–5
140. Wang JS, Fellows DG, Vakharia S, Rosenbaum AE, Thomas PS: Epidural abscess–early magnetic resonance imaging detection and conservative therapy. Anesth Analg 1996; 82:1069–71
141. Watanakunakorn C: Escherichia coli meningitis and septicemia associated with an epidural catheter. Clin Infect Dis 1995; 21:713–4

142. Yaniv LG, Potasman I: Iatrogenic meningitis: an increasing role for resistant viridans streptococci? Case report and review of the last 20 years. Scand J Infect Dis 2000; 32:693–6
143. Yuste M, Canet J, Garcia M, Gil MA, Vidal F: An epidural abscess due to resistant Staphylococcus aureus following epidural catheterisation. Anaesthesia 1997; 52:163–5
144. Simpson J, Foinette KM, Lobo DN, Rowlands BJ: Spinal epidural abscess: adding insult to injury? Injury 1999; 30:504–8
145. Bubeck J, Boos K, Krause H, Thies KC: Subcutaneous tunneling of caudal catheters reduces the rate of bacterial colonization to that of lumbar epidural catheters. Anesth Analg 2004; 99:689–93, table of contents
146. De Cicco M, Matovic M, Castellani GT, Basaglia G, Santini G, Del Pup C, Fantin D, Testa V: Time-dependent efficacy of bacterial filters and infection risk in long-term epidural catheterization. Anesthesiology 1995; 82:765–71
147. Pandian JD, Sarada C, Radhakrishnan VV, Kishore A: Iatrogenic meningitis after lumbar puncture-a preventable health hazard. J Hosp Infect 2004; 56:119–24
148. Sahay BM, Dahake S, Mendiratta DK: Bacteriological profile of epidural catheters. JK Sci 2010; 12:23–26
149. Simpson RS, Macintyre PE, Shaw D, Norton A, McCann JR, Tham EJ: Epidural catheter tip cultures: results of a 4-year audit and implications for clinical practice. Reg Anesth Pain Med 2000; 25:360–7
150. Strafford MA, Wilder RT, Berde CB: The risk of infection from epidural analgesia in children: a review of 1620 cases. Anesth Analg 1995; 80:234–8
151. Conangla G, Rodríguez L, Alonso-Tarrés C, Avila A, de la Campa AG: [Streptococcus salivarius meningitis after spinal anesthesia]. Neurologia 2004; 19:331–3
152. Hadzic A, Koluder-Cimic N, Hadzovic-Cengic M, Gojak R, Gavrankapetanovic I, Becirbegovic S: Serratia marcescens meningitis following spinal anaesthesia and arthroscopy. Med Arch 2012; 66(3 Suppl 1):54–5
153. Halaby T, Leyssius A, Veneman T: Fatal bacterial meningitis after spinal anaesthesia. Scand J Infect Dis 2007; 39:280–3
154. Hoesni S, Bhinder R, Tan T, Hughes N, Carey M: Herpes simplex meningitis after accidental dural puncture during epidural analgesia for labour. Int J Obstet Anesth 2010; 19:466–7
155. Pinczower GR, Gyorke A: Vertebral osteomyelitis as a cause of back pain after epidural anesthesia. Anesthesiology 1996; 84:215–7
156. Cameron CM, Scott DA, McDonald WM, Davies MJ: A review of neuraxial epidural morbidity: experience of more than 8,000 cases at a single teaching hospital. Anesthesiology 2007; 106:997–1002
157. Tung GA, Yim JW, Mermel LA, Philip L, Rogg JM: Spinal epidural abscess: correlation between MRI findings and outcome. Neuroradiology 1999; 41:904–9
158. Alpantaki K, Papoutsidakis A, Katonis P, Hadjipavlou A: Vertebral osteomyelitis, epidural and psoas abscess after epidural catheter use. Acta Orthop Belg 2007; 73:670–3
159. Arun R, Al-Nammari SS, Mehdian SM: Multilevel vertebral osteomyelitis and facet joint infection following epidural catheterisation. Acta Orthop Belg 2007; 73:665–9
160. Dunn LT, Javed A, Findlay G, Green AD: Iatrogenic spinal infection following epidural anaesthesia: case report. Eur Spine J 1996; 5:418–20
161. Flisberg P, Friberg H: Epidural anesthesia complications - early warning signs. Acta Anaesthesiol Scand 2007; 51:264–5
162. Hooten WM, Mizerak A, Carns PE, Huntoon MA: Discitis after lumbar epidural corticosteroid injection: a case report and analysis of the case report literature. Pain Med 2006; 7:46–51
163. Ikushima I, Hirai T, Korogi Y, Norio M, Koganemaru M, Suga R, Morishita S, Yamashita Y: Spinal MR findings in continuous epidural analgesia without infection. AJNR Am J Neuroradiol 2005; 26:991–5
164. Krishnakumar R, Renjitkumar J: Methicillin-Resistant Staphylococcus aureus Vertebral Osteomyelitis Following Epidural Catheterization: A Case Report and Literature Review. Global Spine J 2012; 2:231–4
165. Morau EL, Lotthe AA, Morau DY, Parneix M, Hocquet AF, Colson PH: Bifocal tuberculosis highlighted by obstetric combined spinal-epidural analgesia. Anesthesiology 2005; 103:445–6
166. Noh SH, Heo DH: Whole cerebrospinal axis infection after lumbar epidural injection: a case report. Eur Spine J 2015; 24 Suppl 4:S525–8
167. Okano K, Kondo H, Tsuchiya R, Naruke T, Sato M, Yokoyama R: Spinal epidural abscess associated with epidural catheterization: report of a case and a review of the literature. Jpn J Clin Oncol 1999; 29:49–52
168. Shashidhar N, Tripathy SK, Balasubramanian S, Dhanakodi N, Venkataramaiah S: Aspergillus spondylodiscitis in an immunocompetent patient following spinal anesthesia. Orthop Surg 2014; 6:72–7
169. Yamaguchi M, Kawakubo A, Ide R, Hara K, Sumikawa K: [Epidural abscess associated with epidural block in a patient with immunosuppressive disease]. Masui 1999; 48:506–8
170. Aromaa U, Lahdensuu M, Cozanitis DA: Severe complications associated with epidural and spinal anaesthesias in Finland 1987-1993. A study based on patient insurance claims [see comment]. Acta Anaesthesiol Scand 1997; 41:445–52
171. Kessler AT, Kourtis AP: Treatment of meningitis caused by methicillin-resistant Staphylococcus aureus with linezolid. Infection 2007; 35:271–4
172. Siddiq F, Chowfin A, Tight R, Sahmoun AE, Smego RA Jr: Medical vs surgical management of spinal epidural abscess. Arch Intern Med 2004; 164:2409–12
173. Tabo E, Ohkuma Y, Kimura S, Nagaro T, Arai T: Successful percutaneous drainage of epidural abscess with epidural needle and catheter. Anesthesiology 1994; 80:1393–5
174. Kundra S, Singh RM, Grewal A, Gupta V, Chaudhary AK: Necrotizing fasciitis after spinal anesthesia. Acta Anaesthesiol Scand 2013; 57:257–61