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**Port site infection in laparoscopic surgery: A review of its management**

Sasmal *et al.* Port site infection

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**Abstract**

Laparoscopic surgery also termed minimal access surgery has brought a paradigm shift in the approach to modern surgical; care. Early post-operative recovery, less pain, improved aesthesis and early return to work, have led to its popularity both amongst surgeons and the patients. Its application has progressed from cholecystectomies and appendectomies to various other fields including gastrointestinal surgery, urology, gynecology and oncosurgery. But laparoscopic surgery has its own package of complications. Port site infection (PSI), although infrequent is one of the bothersome complications which undermine the benefits of minimal invasive surgery. Not only does it add to the morbidity of the patient but also spoils the reputation of the surgeon.

Despite the advances in the field of antimicrobial agents, sterilization techniques, surgical techniques, operating room ventilation, PSI still prevail. The emergence of rapid growing atypical mycobacteria with multidrug resistance, as the causative organism in most of the cases, has further compounded the problem. PSIs are preventable if appropriate measures are taken preoperatively, intraoperative and post operatively. It can often be treated non-surgically, with early identification and appropriate management. Macrolides, quinolones and aminoglycosides antibiotics do show promising response against the atypical mycobacteria. This review article highlights the clinical burden, presentations and management of PSIs in laparoscopic surgery as shared by various authors in the literature. We have given emphasis to atypical mycobacteria, which is emerging as a common etiological agent for PSIs in laparoscopic surgery. Although existing literature lacks consensus regarding its management, strictly abiding by the commandments of sterilization techniques of the laparoscopic instruments with appropriate sterilizing agent, the complication can be best avoided.

**Key words:** Laparoscopic surgery; Port site infection; Surgical Site infections; Atypical mycobacteria; Sterilization

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**Core tip:** Laparoscopic surgery has brought about a paradigm shift in the approach to various surgical diseases. Port site infection although infrequent, is a complication which can undermine the benefits of the surgery. The complication is not life threatening, but definitely adds a lot to the morbidity, affects the postoperative quality of life, and spoils the aesthesis of the surgery. Leaving aside the bacterial causes, the rapidly emerging, multidrug resistant, atypical mycobacteria are a constant threat. By doing a thorough review of this topic, this paper aims to present the relevant literature regarding the diagnosis, currently available treatment options and commandments to prevent the occurrence of this somewhat preventable complication.

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**INTRODUCTION**

Rapid growths in health care technology have given the surgeon the power of not only treating the disease surgically but also limiting its invasiveness. The greatest example is minimal access surgery (MAS) also commonly termed as laparoscopic surgery (LS) or keyhole surgery, which has caused a paradigm shift in the approach to modern surgery, by limiting the access related morbidities.

LS involves the use of reusable metallic or disposable plastic trocars inserted through small skin incisions or ports made on the skin away from the site of surgery. This ports form the portal of entry to perform the surgical procedure by means of specially devised instruments and telescope. It has gained popularity due to better aesthesis, lesser pain, early ambulation and discharge from the hospital with early return to work, minimizing the financial burden to the patient. Ever since Philips Mouret reported the first laparoscopic cholecystectomy in 1987, the approach has been adopted for many other surgical procedures including appendectomy, herniorrhaphy, colonic surgery, gastric surgery, urological and gynaecological surgery[1-5]. It is because of the combination of advancement in technology with the increasing acceptance of MAS by the patients, which has led to the expansion of the horizon of LS.

This novel procedure however has its package of unique complications. On**e** such complication, which is preventable although, is the port site infection (PSI). It soon erodes the advantages of LS, with the patient becoming worried with the indolent and nagging infection and losing confidence on the operating surgeon. There occurs a significant increase in the morbidity, hospital stay and financial loss to the patient. The whole purpose of MAS to achieve utmost cosmesis is turned into an unsightly wound and seriously affects the quality of life.

In this article we have reviewed the current literature regarding the incidence, clinical presentation, their etiopathogenesis, management and methods of prevention of PSI in LS. We have emphasized on the management of PSI due to the emerging rapid growing atypical mycobacteria that do not respond to the standard anti-tubercular drugs.

***Incidence of PSIs***

No surgical wound is completely immune to infections. Despite the advances in the field of antimicrobial agents, sterilization techniques, surgical techniques, operating room ventilation, PSI still prevail. Incidence of SSI after elective laparoscopic cholecystectomy is less than that after open elective cholecystectomy due to shorter length of incision[6]. The technique of primary port entry to the peritoneum does not show any difference in umbilical PSIs in patients undergoing laparoscopic cholecystectomy[7]. The umbilical PSI rate in LS has been reported to be 8% with 89% of the infections occurring after laparoscopic cholecystectomy, whereas 11% after laparoscopic appendectomy[8]. Francis *et al*[9] studied the factor predicting 30-d readmission after laparoscopic colorectal cancer surgery. Out of 268 patients in their study, who underwent laparoscopic colorectal surgery, 48 patients (18%) were readmitted with surgical site infection (SSI)[9]. Several other authors have found that SSI rate is much higher in conventional surgical procedures than MAS[10-12]. The immune functions are less affected in LS as compared to open surgery[13]. The incidences of PSI in laparoscopic cholecystectomy as per various studies[14-22] are illustrated in Table 1.

***SSIs and PSIs***

SSIs are infections consequent to the surgery that present within a month of the operative procedure. Surveillance in surgeries related to breast, cardiac, cranial, spinal bones, etc., with use of prosthetic material, extends to 90 d after surgery[23-25].

PSI is a type of SSI but limited to LS. The same criteria of SSI are applicable to PSIs, but the infections are limited to superficial and deep surgical sites only as detailed below.

The Centre for disease Control (CDC), United States definitions of SSIs categorized SSIs into[25]: (1) Superficial SSI which involve skin and subcutaneous tissue; (2) Deep SSI which involve fascia and muscle layers; and (3) Organ/Space SSI.

Wounds are classified as (as per CDC criteria of SSI 2015)[25]: (1) Clean: A surgical wound that is neither exposed to any inflamed tissue nor has breached the gastrointestinal, respiratory, genital, or uninfected urinary tracts; (2) Clean-Contaminated: Surgical wounds where there is controlled entry into the gastrointestinal, respiratory, genital, or uninfected urinary tracts with minimal contamination; (3) Contaminated: Fresh wounds related to trauma, surgical wounds with major breach in sterile technique or gross contamination from the gastrointestinal tract, and incisions through nonpurulent inflammatory tissues; and (4) Dirty or Infected: Old wounds following trauma having devitalized tissue and surgical procedure performed in the presence of active infection or visceral perforation.

Most of the surgical procedures done by laparoscopy belong to Class 1 and 2 types of wound. The human body hosts a variety of microbes which can cause infections. When the host systemic immunity is suppressed due to any disease, medications or disruptions of the integrity of the skin or mucous membranes secondary to surgical insult, patients own commensal microbial flora may cause infection. The PSIs in LS manifests in the form of sero purulent discharge from the port sites with surrounding skin inflammation or symptoms related to the organ/space of infection.

The active surveillance for PSIs in LS remains a challenge, due to the early discharge and day care setting[10,12]. In absence of post-discharge surveillance, it is estimated that a third of all SSIs will be missed[26]. The reported incidence of SSIs varies in various regions of the world. The reported incidence of SSIs in a recent article from Turkey were seen to be higher were higher than the CDC NHSN rates[27]. Hence the actual incidence of the PSIs may be much higher than revealed.

There are more incidences of superficial incisional SSIs as compared to that of deep incisional SSIs in LS[12]. The PSI after a LS should be promptly diagnosed and treated appropriately. Although it may not be possible to achieve zero percent PSI, but every attempt should be made to prevent it. Insight into the pathophysiology of incision site infections, pathogens involved and knowledge the appropriate antibiotic is essential for successful management of PSI in LS.

***Risk factors of PSIs***

A number of contributing factors are somewhat responsible for the emergence of postoperative PSIs. Antibiotics always may not be the answer to this problem. Thus using them irrationally, as is often done will only result in emergence of the multidrug resistant microbes. Majority of the reports of post-operative wound infection, are of the SSIs. PSIs following LS have been less reported. The risk factors of SSIs however may be applicable to PSIs.

**Preoperative stay in hospital:** Lilani *et al*[10] reported significant increase in the incidence of SSIs with preoperative stay of more than 2 d for open surgical procedures.

**Duration of operation:** The study by Lilani *et al*[10] reported nil infection rate in surgeries of less than 30 min duration. There was a significant increase in SSIs for operations of prolonged duration for two hours or more.

**Other factors:** Obesity, prophylactic antibiotic, and drains have no effect on the rate of SSIs following laparoscopic cholecystectomy[28]. Factors like emergency/multi-procedure surgery, surgery in acutely inflamed organs adversely affect the rate of SSIs[20,22]. The risk of SSIs increase in patients with history of nicotine or steroid usage, diabetes, malnutrition, long preoperative hospital stay, preoperative colonization of nares with *Staphylococcus aureus*, and perioperative blood transfusion[29,30].

PSIs are more common in the umbilical port[12]; the infection rate may depend upon the port through which the specimen is extracted. The infected specimen should be removed in an endobag in order to prevent wound infection and accidental spillage of contents or occult malignant cells. An improvised endobag can be prepared from a simple surgical glove which is easy to make, cheap, readily available and disposable[17].

***Microbial flora causing PSIs in LS***

PSIs occur due to exposure of surgical wound to microbes which may be from an endogenous or exogenous source. The source of endogenous flora usually is from the patient’s skin, mucous membranes or any of the viscera. The exogenous flora may be from any contaminated sources present in the sterile surgical field including, surgeon and team, instruments, room air, *etc*.[31].

The pathogenic organisms causing SSIs differ with the surgical procedure performed. Clean surgical wounds usually harbor *Staphylococcus aureus* which may have an exogenous origin or may be from the patient’s native flora. Infections in clean-contaminated, contaminated and dirty surgical wounds, are polymicrobial, resembling the endogenous flora of the target organ[32].

PSIs are of two broad varieties based on the timing when the present. The more common type manifests early, within a week of the surgical procedure. Gram positive or negative bacteria are the usual offending organisms which are contracted from the native skin or infected surgical site. They usually respond well to the commonly used antimicrobial agents. The other variety is caused by rapid growing atypical mycobacterium species, which has an incubation period of 3 to 4 wk. They show poor response to the usual antimicrobial agents[33].

**Non mycobacterial isolates:** Kownhar *et al*[34] reported superficial SSIs as the most common in both MAS and open surgical procedures, with *Staphylococcus aureus* as the commonest isolate. They studied the SSIs to find the various common bacteria isolated as *Staphylococcus aureus* (37%) and *Pseudomonas aeruginosa* (37%), followed by *Klebsiella pneumonia* (8%), *Acinetobacter spp*. (3.2%), *Proteus spp*. (4.8%), *Escherichia coli* (4.8%), *Citrobacter freundii* (1.6%), *Edwardsiella tarda* (1.6%) and *Enterococcus faecalis* (1.6%). *Klebsiella sp.* is the most common offending organism in deep SSIs irrespective of the surgical approach[34]. Usually hospital acquired skin flora cause superficial SSIs. Organisms causing deep SSIs usually are endogenous in origin or may be the skin commensals which reach the fascia or muscle layers through surgical incision[23]. *Bacteroides sp.* were the predominant flora (60%) causing SSIs, in a study reported by [Wolcott](http://www.ncbi.nlm.nih.gov/pubmed/?term=Wolcott%20RD%5BAuthor%5D&cauthor=true&cauthor_uid=19862869) *et al*[35]. *Bacterioides fragilis* may originate from intraoperative visceral spillage. Mir *et al*[15] in their series found pseudomonas (42.2%) as the common offending organism in PSIs following laparoscopic cholecystectomy. They found the organism isolated were resistant to commonly used antibiotics in their hospital[15].

**Mycobacterial isolates:** Several reports have established the role of rapidly growing mycobacteria (RGM), particularly *M. fortuitum* and *M chelonae* which together have been termed as *M. fortuitum-chelonae complex* is known to cause disease in humans as well as animals[36]. The endospores of this non-tuberculous mycobacterial (NTM) complex, usually considered saprophytes which colonize in sewage, soil and even tap water. This often cause localized skin infections 3-4 wk post-surgery[37,38]. The NTM complex can cause disseminated disease in immunosuppressive diseases. These atypical mycobacteria have a predilection to involve the skin and subcutaneous tissue. *M. chelonae* and *M*. *abscessus,* have similar characteristics, and hence together addressed as *M. chelonae*/*abscessus* group. Vijayaraghavan *et al*[39] reported an outbreak laparoscopic PSIs due to *M.* *chelonae* at their center. They had 145 PSIs, in 35 patients in a period of 6-wk. The contaminating source was found to be the water being used for washing instruments after chemical disinfection[39]. A series of eight cases of port site tuberculosis after laparoscopy was reported by Ramesh *et al*[40] from India, caused by *M. tuberculosis*.

A case of PSI following laparoscopic cholecystectomy caused by *M. flavescens* has been reported[41]. Duarte *et al*[42] reported an epidemic (74 cases) of postsurgical infections in Brazil, due to *M. massiliense*, after video assisted surgery, which had similar characteristics to *M. abscessus*. Recently, there have been reports of rapid growing mycobacterial infection following laparoscopic gastric banding in obesity[43,44]. Atypical mycobacteria infection following surgery, although rare, are known to occur when a prosthetic material has been used[45].

***Clinical presentations of PSIs***

Wound discharge and erythema around the port site is the most common presentation of non-mycobacterial infection usually occurring within a week of the surgery. They are usually limited to the skin and subcutaneous tissue[12,14]. There may be surrounding tissue inflammation with pain or tenderness and low grade fever [31].

The delayed type of presentation caused by mycobacteria manifests nearly a month after surgery, in the form of persistent multiple discharging sinuses or lumps/nodules, not responding to antibiotics. There may be pigmentation and induration at the port site starting in a single port and spreading to others.

There are five clinical stages of atypical mycobacterial PSI[46].

**First stage:** A tender nodule appears in vicinity of the port site, its usual time of appearance is around fourth week following the surgery.

**Second stage:** Increase in the size of the nodule, increased tenderness of the site along with other signs of inflammation with eventual formation of a discharging sinus.

**Third stage:** Reduced pain sensation following discharge of the purulent material and necrosis of the skin surrounding the port site.

**Fourth stage:** Chronic sinus discharging white or serous fluid.

**Fifth stage:** Hyper-pigmentation of the skin surrounding the sinus and appearance of multiple nodules at different places.

***Diagnosis of the etiological agent with early management***

**Early PSIs:** Gram stains and culture sensitivity of the pus from port-site wounds are taken. The swabs obtained are processed aerobically and anaerobically by standard methods to find the non-mycobacterial isolates. *Staphylococcus aureus* strains are usually isolated from clean wounds. Their status of β-lactamase production and methicillin resistance needs to be assessed[10]. Daily dressing, cleaning of the wound and a course of empirical antibiotic is started. Specific antibiotic as per the culture and sensitivity report are to be given subsequently Drainage and debridement may sometimes be required for assisting in wound healing. There are reports of port site abscess presenting as discharging sinus months after surgery due to retained stone at the port site. Wound exploration and removal of the stone is necessary for the healing of such wound[47,48]. Samel *et al*[49] reported a case of gas gangrene of the abdominal wall due to *Clostridial* agents centering around right lateral port following laparoscopic cholecystectomy. There are also reports of life threatening necrotizing fasciitis of abdominal following LS. Significant erythema and wound discharge around the port site along with fever are signs of necrotizing fasciitis[50,51]. A high grade of suspicion and aggressive management is necessary to deal with these life threatening bacterial infections.

**Delayed** PSI**s:** Sumit *et al*[46] have shown a raised C-reactive protein level without leukocytosis and a normal differential count in patients with atypical mycobacterial infection[46,52]. Tissue or fluid obtained by biopsy or aspiration need to be processed for baciloscopy and culture in Lowenstein- Jensen (LJ) medium and BACTEC technique (Becton-Dickinson diagnostic Instrument Systems, Sparks, Md). Isolation of the atypical mycobacteria by tissue culture is possible, although it takes time to grow. Moreover maintaining the stringent environment for its culture is difficult. The most accurate method for rapid presumptive identification of *M. chelonae* is detecting resistance to polymyxin B disc (300 μg)[53]. The routine culture of pus does not grow any bacteria. The diagnosis is often based on the clinical signs and a high index of suspicion[52]. In case of growth of the organism, the isolate is to be confirmed by either biochemical reactions or the more recent nucleic acid amplification tests. Other investigations like tissue culture, real time-PCR, serology for antitubercular antibody can support the diagnosis[53]. Even these reports are not full proof, as these tests could give a false positive result. The histopathological examination at times may reveal chronic granulomatous inflammation, comprising of epitheloid cells, lympho-plasmacytic infiltration[40].

***Treatment of PSIs***

Early PSIs, with bacterial isolates, are best managed with local wound care and antibiotics as per antibiogram. Study by Lilani *et al*[10]in clean and clean contaminated cases, revealed *Staphylococcal sp.* as the commonest isolate, and were resistant to penicillin. The isolates of *Pseudomonas aeruginosa* were totally resistant to gentamicin[10]. Mir *et al*[15] found most of the isolated strains of organisms causing SSI in elective laparoscopic cholecystectomy, were resistant to antibiotics used in the hospital. They found the *Pseudomonas sp.* to be sensitive to imipenem in 89.47% cases but there was complete resistance to the combination of ampicillin and sulbactam and ceftrixone [15].

Management of PSIs with atypical mycobacteria lack consensus. They respond poorly to first line anti-tubercular drug treatment. Second line anti-tubercular drugs including macrolides (clarithromycin), quinolones (ciprofloxacin), tetracyclines (doxycycline) and aminiglycosides (amikacin and tobramycin) in various combinations have been used with promising results[37,46,54]. Macrolides including clarithromycin, is the only group of antimicrobials active against *M. chelonae* and *M. abscessus*[54]. *Mycobacterium fortium-chelonae* complex has shown resistance to antibiotics because of mutation in the porin channels present in the bacterial wall, which is the site for entry of antibiotic molecules for antimicrobial activity[46,55]. Linezolid was found to be active against *M. chelonae* and has been successfully used for treatment, alone or as combination therapy[56]. The various antibiotics effectively used against the mycobacterial PSIs, as reported in various studies are described in Table 2.

***Prevention of*** PSI***s***

The million dollar question is why at all there occur PSIs in clean and clean contaminated wounds after LS. Is it because of the contamination from the endogenous source or through exogenous sources? The endogenous source of infection cannot be avoided. But the incidence of PSIs after LS due to endogenous cause can be reduced by using sterile endobag for specimen retrieval.

The exogenous source of infection however is avoidable. Non tuberculous mycobacteria may be present in water from various sources and soil which can contaminate hospital instruments. A breach in sterilization protocol of laparoscopic instruments is the most common cause of PSI with atypical mycobacteria[46]. The infection of atypical mycobacteria is usually limited to the laparoscopic procedure, as the laparoscopic instruments are not autoclavable because of the heat sensitive outer insulation sheath. Moreover the laparoscopic instruments have multiple joints and crevices, where blood and tissue can collect. Frequent use of the instrument without optimal cleaning, potentially results in contamination with organisms such as atypical mycobacteria. Endospores in the contaminated instrument gets deposited in the subcutaneous tissue, which germinates in three to four weeks to produce clinical signs and symptoms[42]. A study by [Lorena](http://www.ncbi.nlm.nih.gov/pubmed/?term=Lorena%20NS%5BAuthor%5D&cauthor=true&cauthor_uid=20877958) *et al*[57] on *M. massiliense* BRA100 strain had shown it’s resistant to even higher concentration of glutaraldehyde (GTA-7%). Hence they proved that GTA may not be effective for RGM. Other liquid sterilizing agent like orthophthaldehyde (OPA) and per acetic acid may substitute GTA for high level disinfection with good efficacy[57].

**Ten commandments for preventing** PSI[58-61]: (1) Use of disposable trocars and instruments. Adequate availability of trocars to cover all the surgical procedures in a day; (2) Use of autoclavable laparoscopic hand instruments; (3) Use of instruments with good ergonomics, limited joints and facility for proper cleaning of the debris collected in its crevices; (4) A proper cleaning of the instrument is best achieved by ultrasonic technology. Use of autoclaved water for cleaning the instruments after dismantling; (5) Proper guidelines should be followed regarding the concentration, contact time and cycles of use for instrument sterilization with liquid sterilizing agents; (6) Use of plasma sterilizer or ethylene oxide in between the consecutive surgery for instrument sterilization; (7) Avoiding inter-departmental sharing of instruments, such as using instruments used for gynecological or urological procedures; (8) Avoiding spillage of bile or gut content in the operative area or the port site; (9) Use of non-porous specimen retrieval bags for retrieving the specimen; and (10) Thorough irrigation and cleaning of the port site before wound closure.

**CONCLUSION**

PSI, although infrequent, can be a frustrating complication in MAS, both for the patient as well as the operating surgeon. Leaving aside the bacterial causes, the emerging rapid growing multidrug resistant non-tuberculous mycobacteria are a new threat to the surgical fraternity. Strictly abiding by the commandments of cleaning and sterilization of the laparoscopic instruments, with the appropriate sterilizing agent, the complication can be best avoided.

This review is likely to aid in understanding the relevant studies regarding the appropriate management of PSIs in LS. All the cases of PSI, especially of the atypical mycobacterium should be notified to know the exact incidence, etiology and the sensitivity pattern to various antibiotics. Macrolides, quinolones and aminoglycosides antibiotics do show promising response against the atypical mycobacterium. Further research is needed to find out appropriate guidelines for the diagnosis and treatment of this emerging problem.

**REFERENCES**

1 **Lei QC**, Wang XY, Zheng HZ, Xia XF, Bi JC, Gao XJ, Li N. Laparoscopic Versus Open Colorectal Resection Within Fast Track Programs: An Update Meta-Analysis Based on Randomized Controlled Trials. *J Clin Med Res* 2015; **7**: 594-601 [PMID: 26124904 DOI: 10.14740/jocmr2177w]

2 **Deng Y,** Zhang Y, Guo TK. Laparoscopy-assisted versus open distal gastrectomy for early gastric cancer: A meta-analysis based on seven randomized controlled trials. *Surg Oncol* 2015; **24**: 71-77 [PMID: 25791201 DOI: 10.1016/j.suronc.2015.02.003]

3 **Mehrabi A**, Hafezi M, Arvin J, Esmaeilzadeh M, Garoussi C, Emami G, Kössler-Ebs J, Müller-Stich BP, Büchler MW, Hackert T, Diener MK. A systematic review and meta-analysis of laparoscopic versus open distal pancreatectomy for benign and malignant lesions of the pancreas: it's time to randomize. *Surgery* 2015; **157**: 45-55 [PMID: 25482464 DOI: 10.1016/j.surg.2014.06.081]

4 **Bhave Chittawar P**, Franik S, Pouwer AW, Farquhar C. Minimally invasive surgical techniques versus open myomectomy for uterine fibroids. *Cochrane Database Syst Rev* 2014; **10**: CD004638 [PMID: 25331441 DOI: 10.1002/14651858.CD004638.pub3]

5 **Esposito C**, St Peter SD, Escolino M, Juang D, Settimi A, Holcomb GW. Laparoscopic versus open inguinal hernia repair in pediatric patients: a systematic review. *J Laparoendosc Adv Surg Tech A* 2014; **24**: 811-818 [PMID: 25299121 DOI: 10.1089/lap.2014.0194]

6 **Zacks SL**, Sandler RS, Rutledge R, Brown RS. A population-based cohort study comparing laparoscopic cholecystectomy and open cholecystectomy. *Am J Gastroenterol* 2002; **97**: 334-340 [PMID: 11866270]

7 **Molloy D**, Kaloo PD, Cooper M, Nguyen TV. Laparoscopic entry: a literature review and analysis of techniques and complications of primary port entry. *Aust N Z J Obstet Gynaecol* 2002; **42**: 246-254 [PMID: 12230057]

8 **Hamzaoglu I**, Baca B, Böler DE, Polat E, Ozer Y. Is umbilical flora responsible for wound infection after laparoscopic surgery? *Surg Laparosc Endosc Percutan Tech* 2004; **14**: 263-267 [PMID: 15492655]

9 **Francis NK**, Mason J, Salib E, Allanby L, Messenger D, Allison AS, Smart NJ, Ockrim JB. Factors predicting 30-day readmission after laparoscopic colorectal cancer surgery within an enhanced recovery programme. *Colorectal Dis* 2015; **17**: O148-O154 [PMID: 25988303 DOI: 10.1111/codi.13002]

10 **Lilani SP**, Jangale N, Chowdhary A, Daver GB. Surgical site infection in clean and clean-contaminated cases. *Indian J Med Microbiol* 2005; **23**: 249-252 [PMID: 16327121]

11 **Brill A**, Ghosh K, Gunnarsson C, Rizzo J, Fullum T, Maxey C, Brossette S. The effects of laparoscopic cholecystectomy, hysterectomy, and appendectomy on nosocomial infection risks. *Surg Endosc* 2008; **22**: 1112-1118 [PMID: 18297345 DOI: 10.1007/s00464-008-9815-1]

12 **Richards C**, Edwards J, Culver D, Emori TG, Tolson J, Gaynes R. Does using a laparoscopic approach to cholecystectomy decrease the risk of surgical site infection? *Ann Surg* 2003; **237**: 358-362 [PMID: 12616119]

13 **Redmond HP**, Watson RW, Houghton T, Condron C, Watson RG, Bouchier-Hayes D. Immune function in patients undergoing open vs laparoscopic cholecystectomy. *Arch Surg* 1994; **129**: 1240-1246 [PMID: 7986152 DOI: 10.1001/archsurg.1994.01420360030003]

14 **Karthik S**, Augustine AJ, Shibumon MM, Pai MV. Analysis of laparoscopic port site complications: A descriptive study. *J Minim Access Surg* 2013; **9**: 59-64 [PMID: 23741110 DOI: 10.4103/0972-9941.110964]

15 **Mir MA**, Malik UY, Wani H, Bali BS. Prevalence, pattern, sensitivity and resistance to antibiotics of different bacteria isolated from port site infection in low risk patients after elective laparoscopic cholecystectomy for symptomatic cholelithiasis at tertiary care hospital of Kashmir. *Int Wound J* 2013; **10**: 110-113 [PMID: 22414004 DOI: 10.1111/j.1742-481X.2012.00963.x]

16 **Yanni F**, Mekhail P, Morris-Stiff G. A selective antibiotic prophylaxis policy for laparoscopic cholecystectomy is effective in minimising infective complications. *Ann R Coll Surg Engl* 2013; **95**: 345-348 [PMID: 23838497 DOI: 10.1308/003588413X13629960045959]

17 **Taj MN**, Iqbal Y, Akbar Z. Frequency and prevention of laparoscopic port site infection. *J Ayub Med Coll Abbottabad* 2012; **24**: 197-199 [PMID: 24669653]

18 **Yi F**, Jin WS, Xiang DB, Sun GY, Huaguo D. Complications of laparoscopic cholecystectomy and its prevention: a review and experience of 400 cases. *Hepatogastroenterology* 2012; **59**: 47-50 [PMID: 22260821 DOI: 10.5754/hge11232]

19 **Triantafyllidis I**, Nikoloudis N, Sapidis N, Chrissidou M, Kalaitsidou I, Chrissidis T. Complications of laparoscopic cholecystectomy: our experience in a district general hospital. *Surg Laparosc Endosc Percutan Tech* 2009; **19**: 449-458 [PMID: 20027087 DOI: 10.1097/SLE.0b013e3181bd8f6d]

20 **Chuang SC**, Lee KT, Chang WT, Wang SN, Kuo KK, Chen JS, Sheen PC. Risk factors for wound infection after cholecystectomy. *J Formos Med Assoc* 2004; **103**: 607-612 [PMID: 15340659]

21 **Shindholimath VV**, Seenu V, Parshad R, Chaudhry R, Kumar A. Factors influencing wound infection following laparoscopic cholecystectomy. *Trop Gastroenterol* 2003; **24**: 90-92 [PMID: 14603831]

22 **den Hoed PT**, Boelhouwer RU, Veen HF, Hop WC, Bruining HA. Infections and bacteriological data after laparoscopic and open gallbladder surgery. *J Hosp Infect* 1998; **39**: 27-37 [PMID: 9617682]

23 **Rubin RH**. Surgical wound infection: epidemiology, pathogenesis, diagnosis and management. *BMC Infect Dis* 2006; **6**: 171 [PMID: 17129369 DOI: 10.1186/1471-2334-6-171]

24 **Horan TC**, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. *Am J Infect Control* 2008; **36**: 309-332 [PMID: 18538699 DOI: 10.1016/j.ajic.2008.03.002]

25 **Centers for Disease Control and Prevention**. The National Healthcare Safety Network (NHSN) Manual: Patient Safety Component Atlanta, GA: Division of Healthcare Quality Promotion, National Centerfor Emerging and Zoonotic Infections Diseases. Available from: URL: http://www.cdc.gov/nhsn/acute-care-hospital/index.html

26 **Stockley JM**, Allen RM, Thomlinson DF, Constantine CE. A district general hospital's method of post-operative infection surveillance including post-discharge follow-up, developed over a five-year period. *J Hosp Infect* 2001; **49**: 48-54 [PMID: 11516186 DOI: 10.1053/jhin.2001.1029]

27 **Leblebicioglu H**, Erben N, Rosenthal VD, Sener A, Uzun C, Senol G, Ersoz G, Demirdal T, Duygu F, Willke A, Sirmatel F, Oztoprak N, Koksal I, Oncul O, Gurbuz Y, Güçlü E, Turgut H, Yalcin AN, Ozdemir D, Kendirli T, Aslan T, Esen S, Ulger F, Dilek A, Yilmaz H, Sunbul M, Ozgunes I, Usluer G, Otkun M, Kaya A, Kuyucu N, Kaya Z, Meric M, Azak E, Yýlmaz G, Kaya S, Ulusoy H, Haznedaroglu T, Gorenek L, Acar A, Tutuncu E, Karabay O, Kaya G, Sacar S, Sungurtekin H, Uğurcan D, Turhan O, Kaya S, Gumus E, Dursun O, Geyik MF, Şahin A, Erdogan S, Ince E, Karbuz A, Çiftçi E, Taşyapar N, Güneş M. Surgical site infection rates in 16 cities in Turkey: findings of the International Nosocomial Infection Control Consortium (INICC). *Am J Infect Control* 2015; **43**: 48-52 [PMID: 25564124 DOI: 10.1016/j.ajic.2014.09.017]

28 **Scott JD**, Forrest A, Feuerstein S, Fitzpatrick P, Schentag JJ. Factors associated with postoperative infection. *Infect Control Hosp Epidemiol* 2001; **22**: 347-351 [PMID: 11519911 DOI: 10.1086/501911]

29 **Owens CD**, Stoessel K. Surgical site infections: epidemiology, microbiology and prevention. *J Hosp Infect* 2008; **70** Suppl 2: 3-10 [PMID: 19022115 DOI: 10.1016/S0195-6701(08)60017-1]

30 **Boni L**, Benevento A, Rovera F, Dionigi G, Di Giuseppe M, Bertoglio C, Dionigi R. Infective complications in laparoscopic surgery. *Surg Infect* (Larchmt) 2006; **7** Suppl 2: S109-S111 [PMID: 16895490 DOI: 10.1089/sur.2006.7.s2-109]

31 **Mangram AJ**, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for Prevention of Surgical Site Infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. *Am J Infect Control* 1999; **27**: 97-132; quiz 133-134; discussion 96 [PMID: 10196487]

32 **Nichols RL**. Surgical wound infection. *Am J Med* 1991; **91**: 54S-64S [PMID: 1928192]

33 **Falkinham JO**. Epidemiology of infection by nontuberculous mycobacteria. *Clin Microbiol Rev* 1996; **9**: 177-215 [PMID: 8964035]

34 **Kownhar H**, Shankar EM, Vignesh R, Sekar R, Velu V, Rao UA. High isolation rate of Staphylococcus aureus from surgical site infections in an Indian hospital. *J Antimicrob Chemother* 2008; **61**: 758-760 [PMID: 18199563 DOI: 10.1093/jac/dkm519]

35 **Wolcott RD**, Gontcharova V, Sun Y, Zischakau A, Dowd SE. Bacterial diversity in surgical site infections: not just aerobic cocci any more. *J Wound Care* 2009; **18**: 317-323 [PMID: 19862869]

36 **Muthusami JC**, Vyas FL, Mukundan U, Jesudason MR, Govil S, Jesudason SR. Mycobacterium fortuitum: an iatrogenic cause of soft tissue infection in surgery. *ANZ J Surg* 2004; **74**: 662-666 [PMID: 15315567 DOI: 10.1111/j.1445-1433.2004.03018.x]

37 **Verghese S**, Agrawal P, Benjamin S. Mycobacterium chelonae causing chronic wound infection and abdominal incisional hernia. *Indian J Pathol Microbiol* 2014; **57**: 335-337 [PMID: 24943783 DOI: 10.4103/0377-4929.134736]

38 **Khan IU**, Selvaraju SB, Yadav JS. Occurrence and characterization of multiple novel genotypes of Mycobacterium immunogenum and Mycobacterium chelonae in metalworking fluids. *FEMS Microbiol Ecol* 2005; **54**: 329-338 [PMID: 16332331 DOI: 10.1016/j.femsec.2005.04.009]

39 **Vijayaraghavan R**, Chandrashekhar R, Sujatha Y, Belagavi CS. Hospital outbreak of atypical mycobacterial infection of port sites after laparoscopic surgery. *J Hosp Infect* 2006; **64**: 344-347 [PMID: 17046106]

40 **Ramesh H**, Prakash K, Lekha V, Jacob G, Venugopal A, Venugopal B. Port-site tuberculosis after laparoscopy: report of eight cases. *Surg Endosc* 2003; **17**: 930-932 [PMID: 12618936 DOI: 10.1007/s00464-002-9057-6]

41 **Sethi S**, Gupta V, Bhattacharyya S, Sharma M. Post-laparoscopic wound infection caused by scotochromogenic nontuberculous Mycobacterium. *Jpn J Infect Dis* 2011; **64**: 426-427 [PMID: 21937826]

42 **Duarte RS**, Lourenço MC, Fonseca Lde S, Leão SC, Amorim Ede L, Rocha IL, Coelho FS, Viana-Niero C, Gomes KM, da Silva MG, Lorena NS, Pitombo MB, Ferreira RM, Garcia MH, de Oliveira GP, Lupi O, Vilaça BR, Serradas LR, Chebabo A, Marques EA, Teixeira LM, Dalcolmo M, Senna SG, Sampaio JL. Epidemic of postsurgical infections caused by Mycobacterium massiliense. *J Clin Microbiol* 2009; **47**: 2149-2155 [PMID: 19403765 DOI: 10.1128/JCM.00027-09]

43 **Callen EC**, Kessler TL. Mycobacterium fortuitum infections associated with laparoscopic gastric banding. *Obes Surg* 2011; **21**: 404-406 [PMID: 20336391 DOI: 10.1007/s11695-010-0123-1]

44 **Wright HL**, Thomson RM, Reid AB, Carter R, Bartley PB, Newton P, Coulter C. Rapidly growing mycobacteria associated with laparoscopic gastric banding, Australia, 2005-2011. *Emerg Infect Dis* 2014; **20**: 1612-1619 [PMID: 25279450 DOI: 10.3201/eid2010.140077]

45 **Phillips MS**, von Reyn CF. Nosocomial infections due to nontuberculous mycobacteria. *Clin Infect Dis* 2001; **33**: 1363-1374 [PMID: 11550115 DOI: 10.1086/323126]

46 **Chaudhuri S**, Sarkar D, Mukerji R. Diagnosis and management of atypical mycobacterial infection after laparoscopic surgery. *Indian J Surg* 2010; **72**: 438-442 [PMID: 22131651 DOI: 10.1007/s12262-010-0164-7]

47 **Dreznik Z**, Soper NJ. Trocar site abscess due to spilled gallstones: an unusual late complication of laparoscopic cholecystectomy. *Surg Laparosc Endosc* 1993; **3**: 223-224 [PMID: 8111563]

48 **Narreddy SR**, Guleria S, Agarwal S, Svr CM, Mandal S. Recurrent abscess at site of laparoscopic cholecystectomy port due to spilled gallstones. *Indian J Gastroenterol* 2001; **20**: 161 [PMID: 11497181]

49 **Samel S**, Post S, Martell J, Becker H. Clostridial gas gangrene of the abdominal wall after laparoscopic cholecystectomy. *J Laparoendosc Adv Surg Tech A* 1997; **7**: 245-247 [PMID: 9448120]

50 **Raghavendra GK**, Mills S, Carr M. Port site necrotising fasciitis following laparoscopic appendicectomy. *BMJ Case Rep* 2010; **2010**: [PMID: 22778196 DOI: 10.1136/bcr.10.2009.2375]

51 **Losanoff JE**, Richman BW, Jones JW. Trocar-site hernia complicated by necrotizing fasciitis--case report and review of the literature. *Hernia* 2003; **7**: 220-223 [PMID: 12687429 DOI: 10.1007/s10029-003-0133-1]

52 **Jayashree KV**, Appalaraju B, Jayalakshmi J, Sowmya N, Jayachandran K, Balashanmugam TS, Ramanathan RM. When molecular diagnosis went wrong. *Indian J Pathol Microbiol* 2011; **54**: 418-419 [PMID: 21623117 DOI: 10.4103/0377-4929.81605]

53 **Park SH**, Kim CK, Jeong HR, Son H, Kim SH, Park MS. Evaluation and comparison of molecular and conventional diagnostic tests for detecting tuberculosis in Korea, 2013. *Osong Public Health Res Perspect* 2014; **5**: S3-S7 [PMID: 25861577 DOI: 10.1016/j.phrp.2014.10.006]

54 **Wallace RJ**, Meier A, Brown BA, Zhang Y, Sander P, Onyi GO, Böttger EC. Genetic basis for clarithromycin resistance among isolates of Mycobacterium chelonae and Mycobacterium abscessus. *Antimicrob Agents Chemother* 1996; **40**: 1676-1681 [PMID: 8807061]

55 **Svetlíková Z**, Skovierová H, Niederweis M, Gaillard JL, McDonnell G, Jackson M. Role of porins in the susceptibility of Mycobacterium smegmatis and Mycobacterium chelonae to aldehyde-based disinfectants and drugs. *Antimicrob Agents Chemother* 2009; **53**: 4015-4018 [PMID: 19581465 DOI: 10.1128/AAC.00590-09]

56 **Wallace RJ**, Brown-Elliott BA, Ward SC, Crist CJ, Mann LB, Wilson RW. Activities of linezolid against rapidly growing mycobacteria. *Antimicrob Agents Chemother* 2001; **45**: 764-767 [PMID: 11181357 DOI: 10.1128/AAC.45.3.764-767.2001]

57 **Lorena NS**, Pitombo MB, Côrtes PB, Maya MC, Silva MG, Carvalho AC, Coelho FS, Miyazaki NH, Marques EA, Chebabo A, Freitas AD, Lupi O, Duarte RS. Mycobacterium massiliense BRA100 strain recovered from postsurgical infections: resistance to high concentrations of glutaraldehyde and alternative solutions for high level disinfection. *Acta Cir Bras* 2010; **25**: 455-459 [PMID: 20877958 DOI: 10.1590/S0102-86502010000500013]

58 **Rutala WA**, Weber DJ. Disinfection and sterilization in health care facilities: what clinicians need to know. *Clin Infect Dis* 2004; **39**: 702-709 [PMID: 15356786 DOI: 10.1086/423182]

59 **Mukhopadhyay S**, Basu D, Chakrabarti P. Characterization of a porin from Mycobacterium smegmatis. *J Bacteriol* 1997; **179**: 6205-6207 [PMID: 9324274]

60 **Danilchanka O**, Pavlenok M, Niederweis M. Role of porins for uptake of antibiotics by Mycobacterium smegmatis. *Antimicrob Agents Chemother* 2008; **52**: 3127-3134 [PMID: 18559650 DOI: 10.1128/AAC.00239-08]

61 **Shah AK**, Gambhir RP, Hazra N, Katoch R. Non tuberculous mycobacteria in surgical wounds- a rising cause of concern? *Indian J Surg* 2010; **72**: 206-210 [PMID: 23133248 DOI: 10.1007]

62 **Rajini M**, Prasad SR, Reddy RR, Bhat RV, Vimala KR. Postoperative infection of laparoscopic surgery wound due to Mycobacterium chelonae. *Indian J Med Microbiol* 2007; **25**: 163-165 [PMID: 17582193 DOI: 10.4103/0255-0857.32729]

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**Table 1 Studies showing frequency of port site infection following laparoscopic cholecystectomy**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sl No** | **Ref.** | **Year of publication** | **Type of study** | **Total number of patients** | **Frequency of infection** |
|  |  |  |  |  |  |
| 1 | Karthik *et al*[14] | 2013 | Prospective | 570 | 10 (1.8%) |
| 2 | Mir *et al*[15] | 2013 | Prospective | 675 | 45 (6.7) |
| 3 | Yanni *et al*[16] | 2013 | Prospective | 100 | 4 (4%) |
| 4 | Taj *et al*[17] | 2012 | Observational | 492 | 27 (5.48%) |
| 5 | Yi *et al*[18] | 2012 | NA | 400 | 11 (2.75%) |
| 6 | Triantafyllidis *et al*[19] | 2009 | Retrospective | 1009 | 14 (1.39%) |
| 7 | Chuang *et al*[20] | 2004 | NA | 420 | 6 (1.4%) |
| 8 | Shindholimath *et al*[21] | 2003 | Prospective | 113 | 7 (6.3%) |
| 9 | Den Hoed *et al*[22] | 1998 | Prospective | 119 | 10 (5.3%) |

NA: Not available.

**Table 2 Table highlighting the different antibiotics effectively used against *Mycobacterial sp*. in port site infections**

|  |  |  |  |
| --- | --- | --- | --- |
| **Ref.** | **Type of study** | **Mycobacteria isolated** | **Treatment given** |
| Ramesh *et al*[40] | Case series in 8 patients | *M. tuberculosis* | Standard first line antitubercular regimen4 drugs-rifampicin, isoniazid, pyrazinamide and ethambutol for 2 mo followed by 2 drugs- rifampicin and isoniazid for 9 mo |
| Sumit *et al*[46] | Case series in 19 patients | Clinically suspected atypical mycobacterial infection. No isolates in culture | Clarithromycin and ciprofloxacin (500 mg each, twice daily) for 28 to 3 mo For persistent local nodules, direct injection of amikacin injections into the the nodules daily for 5 d ( 500 mg twice daily)  |
| Verghese *et al*[37] | Case report | *M. chelonae* | Amikacin 750 mg/d and Azithromycin 500 mg BD for 2 wkFollowed by Linezolid 500 mg BD and Azithromycin 500 mg BD for 6 wk |
| Duarte *et al*[42]  | Case series in 74 patients | *M. massiliense* | Sensitive to amikacin and clarithromycin, but resistant to ciprofloxacin, cefoxitine and doxycycline |
| Sethi *et al*[41]  | Case report | *M. flavescens* | Ofloxacin and amikacin for 6 mo |
| Amit *et al*[61] | Case series in 7 patients | *M. fortuitum**M. chelonae* | Clarithromycin and ciprofloxacin (500 mg each, twice daily) for 6-9 mo |
| [Rajini](http://www.ncbi.nlm.nih.gov/pubmed/?term=Rajini%20M%5BAuthor%5D&cauthor=true&cauthor_uid=17582193) *et al*[62] | Case report | *M. chelonae* | Clarithromycin 500 mg BD and doxycycline 100 mg OD for 4 wk |