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Management of intra-abdominal-infections: 2017 World Society of Emergency Surgery guidelines summary focused on remote areas and low-income nations

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ABSTRACT

Background: Most remote areas have restricted access to healthcare services and are too small and remote to sustain specialist services. In 2017, the World Society of Emergency Surgery (WSES) published guidelines for the management of intra-abdominal infections. Many hospitals, especially those in remote areas, continue to face logistical barriers, leading to an overall poorer adherence to international guidelines.
Methods: The aim of this paper is to report and amend the 2017 WSES guidelines for the management of intra-abdominal infections, extending these recommendations for remote areas and low-income

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countries. A literature search of the PubMed/MEDLINE databases was conducted covering the period up until June 2020.
Results: The critical shortages of healthcare workers and material resources in remote areas require the use of a robust triage system. A combination of abdominal signs and symptoms with early warning signs may be used to screen patients needing immediate acute care surgery. A tailored diagnostic step-up approach based on the hospital's resources is recommended. Ultrasound and plain X-ray may be useful diagnostic tools in remote areas. The source of infection should be totally controlled as soon as possible.
Conclusions: The cornerstones of effective treatment for intra-abdominal infections in remote areas include early diagnosis, prompt resuscitation, early source control, and appropriate antimicrobial therapy. Standardization in applying the guidelines is mandatory to adequately manage intra-abdominal infections.

Introduction

Remote areas have been defined as places far from the desirable availability of quality of care and not as lost places distant from a place of care (Ronsmans et al., 2006; Kunst and Houweling, 2001).

In 2010, the World Health Organization (WHO) reported that the prevalence of healthcare-associated infections was higher in low- and middle-income countries than in high-income countries (WHO, 2011; Allegranzi et al., 2011). Surgical site infections (SSI) are the most frequent healthcare-associated infections in low-income countries (LICs) (Bagheri Nejad et al., 2011; ECDC, 2013).

Rural and remote areas share common issues of dispersed and isolated populations, which make the delivery of healthcare to these areas challenging and poorly accessible (Godden, 2005; Swindlehurst et al., 2005). Most remote areas in both LICs and developed countries have restricted access to healthcare services and are too small and remote to sustain specialist services. The access to lifesaving and disability-preventing surgical services is often poor (Glazebrook and Harrison, 2006).

LICs tend to have a worse health status than countries with sound economies (Buor and Bream, 2004; Evans et al., 2001). Elective surgery in LICs is considered a luxury, but the surgery required in remote areas worldwide does not differ from the surgery carried out in large cities (D'Agostino et al., 2001; Padrón-Arredondo, 2006).

In 2016, the WHO published new recommendations on preoperative measures for the prevention of SSI based only on urban models, but not including rural areas (Allegranzi et al., 2016a, 2016b; Berkowitz, 2004). As described in the 2017 World Society of Emergency Surgery (WSES) guidelines for the management of intra-abdominal infections (IAI), complicated intra-abdominal infections (cIAI) are an important cause of

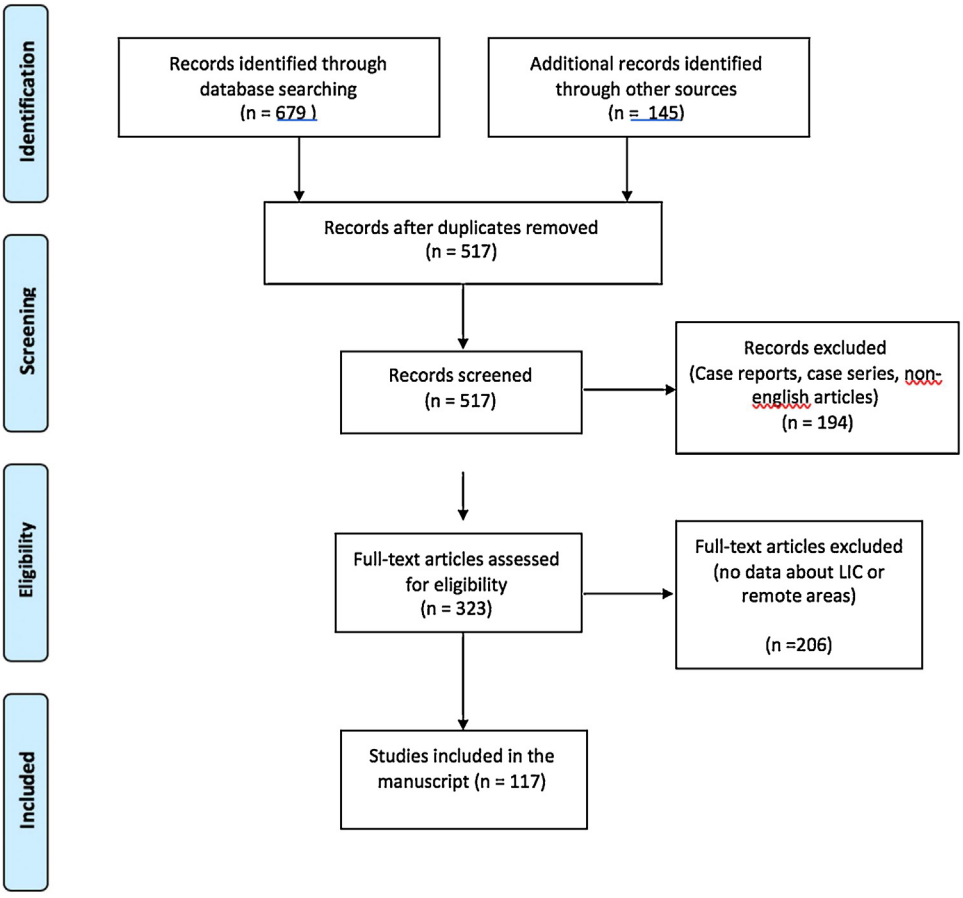

Figure 1. PRISMA flow-chart.

morbidity and mortality, particularly if poorly managed. Many hospitals continue to face logistical barriers associated with the application of evidence-based practice. This may lead to an overall poorer adherence to international guidelines, making them impractical for a large part of the world's population (Sartelli et al., 2017).

Methods

The aim of this paper is to report and amend the 2017 WSES guidelines for the management of IAIs (Sartelli et al., 2017), extending the recommendations to remote areas. An extensive bibliographic review of the literature according to the PRISMA criteria was performed (Figure 1).

The literature search was performed using PubMed/MEDLINE databases and covered the period up until June 2020. The following combination of key terms was used: “remote areas”, “rural areas”, “surgical infections”, “antibiotics”, “intra-abdominal infections”, “acute appendicitis”, “acute diverticulitis”, “gastrointestinal perforations”, “acute calculous cholecystitis”, and “abdominal tuberculosis”.

Based on the 2017 WSES guidelines, an analysis and evaluation of the treatment of several conditions and how they could be improved in remote areas and LICs was conducted.

Results and discussion

Principles of sepsis control

Abdominal sepsis may lead to the functional impairment of one or more vital organs or systems. Since the first classification in 1991 (Bone et al., 1992), the need for early recognition has always been stressed. In LICs, early recognition is mandatory. In remote areas, a robust triage system based on physical examination findings should be instituted due to the critical shortages of both healthcare workers and material resources. A feasible and rapid low-cost method is crucial to identify patients requiring critical care and transfer them immediately to an acute care unit (Rello and Leblebicioglu, 2016).

In this context, smartphone health informatics may direct medical attention to the patient at risk of sepsis through the direct recording of physiological parameters (Fraser and Blaya, 2010).

The q-SOFA score and modified q-SOFA score, such as the quick SOFA-65 score (Singer et al., 2016; Lee and Song, 2020), are potentially not accessible everywhere; in particular, PaO_2 may be difficult to determine as it requires an arterial blood gas measurement.

Easy-to-measure physiological parameters, such as the assessment of systolic blood pressure, pulse rate, respiratory rate, temperature, oxygen saturation, and level of consciousness, should be recognized first as early warning scores. The combination of abdominal signs and symptoms with early warning scores may be used to screen patients who need immediate acute care surgery (Kruisselbrink et al., 2016).

The early recognition of patients with ongoing abdominal sepsis is an essential step for effective treatment. Despite recommendations for the management of sepsis published by several scientific societies (Dellinger et al., 2013; Rhodes et al., 2017), many studies have reported that these guidelines cannot be implemented in remote areas, due to the drastic shortage of required hospital facilities, equipment, drugs, and disposable materials (Bataar et al., 2010; Baelani et al., 2011; Taniguchi et al., 2019; Schultz et al., 2017).

A ‘universal vital assessment’ (UVA) score has been proposed to identify patients at risk of death in Sub-Saharan Africa (Moore et al., 2017).

In patients with abdominal sepsis requiring urgent surgical intervention, overly aggressive fluid resuscitation may increase intra-abdominal pressure and worsen the inflammatory response, which is associated with a high risk of complications such as intra-abdominal hypertension and abdominal compartment syndrome (Marik and Bellomo, 2016; Sartelli et al., 2014). Clinical endpoints in monitoring fluid volume infusions should include mean arterial pressure, skin color and capillary refill, mental status, and urinary output.

To optimize blood flow in the case of persistent hypotension, vasopressor agents should be administered. Adrenaline is the inotrope of choice in LICs due to its availability, low cost, and its equivalent action when compared to noradrenaline in septic shock (Annane et al., 2007).

Diagnosis

According to the 2017 WSES guidelines (Sartelli et al., 2017), a tailored step-up approach based on the hospital's resources is recommended. The diagnosis of IAIs is based primarily on clinical assessment. Diagnostic delay significantly reduces the rate of survival of patients globally (Chichom-Mefire et al., 2016).

Due to the unavailability of adequate resources in rural areas, basic laboratory tests and ultrasound should always be performed. Ultrasound is available worldwide due to its lower cost compared to other diagnostic tests (Ademola et al., 2015; Sippel et al., 2011; Shah et al., 2015). Plain X-ray of the abdomen is also an important diagnostic tool in remote areas, due to its cost-effectiveness, allowing efficient use of resources (LaGrone et al., 2012).

Source control

The timing and adequacy of source control are important in the management of IAIs. Late and/or incomplete procedures may have severely adverse consequences on outcomes, especially in critically ill patients.

IAIs include several different pathological conditions and they are usually classified into uncomplicated and complicated. In uncomplicated IAI, the infectious process involves a single organ and does not proceed to the peritoneum. Patients with such infections can be managed with either surgical source control or with antibiotics alone. In complicated IAI (cIAI), the infectious process extends beyond the organ and causes either localized peritonitis or diffuse peritonitis. The treatment of these patients involves both source control and antibiotic therapy (Sartelli, 2010).

As a general principle, the most established source of infection should be totally controlled as soon as possible. Early administration of appropriate empirical antibiotics for bacterial sepsis is strongly associated with reduced mortality in high-income settings (Seymour et al., 2017). The administration of empirical antibiotics within the first hour of sepsis recognition was recommended in the 2011 WHO IMAI guidelines (Integrated Management of Adolescent and Adult Illness) for remote areas (World Health Organization, 2011a). Despite these recommendations, antimicrobial administration in remote areas such as Sub-Saharan Africa follows a ‘step-up’ approach to limit expensive and complex treatment, but this promotes a harmful treatment delay (Jacob et al., 2009; Cheng et al., 2008).

Source control encompasses all measures undertaken to eliminate the source of infection, reduce the bacterial inoculum, and correct or control anatomical derangements to restore normal physiological function (Marshall, 2010).

The primary objectives of intervention include (1) determining the cause of peritonitis, (2) draining fluid collections, and (3) controlling the origin of the abdominal sepsis. This endeavor generally involves the drainage of abscesses or infected fluid

collections, debridement of necrotic or infected tissues, and definitive control of the source of contamination. Control of the septic source can be achieved either by surgical or non-surgical means.

Laparoscopy has been gaining wider acceptance in the diagnosis and treatment of lAIs (Agresta et al., 2006). In remote areas, laparoscopy remains uncommon due to its higher cost. Some studies have developed low-cost equipment with the aim of making the laparoscopic approach more accessible in resource-poor countries (Jawale and Jesudian, 2019; Bedada et al., 2015; Gyedu et al., 2015).

Acute appendicitis

Acute appendicitis is the most common cause of intra-abdominal sepsis and up to one-third of these cases are complicated, as confirmed by the 2015 WISS study (Sartelli et al., 2015). The incidence of acute appendicitis is changing worldwide. Sub-Saharan Africa and many regions of Asia and Latin America have a low incidence rate. The incidence appears to be increasing in many urban centers and also in low- and middle-income countries, especially in newly industrialized countries in Asia (South Korea), the Middle East (Turkey), and South America (Chile), perhaps due to changes in lifestyle and diet (Ferris and Ghosh, 2017; Edino et al., 2004).

However, the true incidence of appendicitis in many areas of the world remains unknown due to the poor medical record-keeping and unreliable population census. A retrospective study performed in South Africa (2015) reported that rural patients had a longer median duration of illness compared to urban patients (3 versus 5 days), as well as a more advanced disease profile associated with perforation and severe intra-abdominal sepsis (19% versus 71%) (Kong et al., 2015).

Unfortunately, the clinical presentation of appendicitis is inconsistent, and atypical presentations often result in a delay in treatment. A clinical scoring system could optimize the diagnosis, especially in remote areas.

As suggested in the 2020 update of the WSES Jerusalem guidelines, clinical scores alone appear to be sufficiently sensitive to identify low-risk patients and decrease the need for imaging and negative surgical explorations in patients with suspected acute appendicitis (Di Saverio et al., 2020). The Alvarado score (Alvarado, 1986) and the Raja Isteri Pengiran Anak Saleha Appendicitis (RIPASA) score were tested in different LICs, with several discrepancies found between the patient populations. The RIPASA score results were better than the Alvarado score results in Asian (Chong et al., 2010) and Indian (Nanjundaiah et al., 2014) populations. The Modified Alvarado Scoring System (MASS) had a sensitivity of 94.1% and a specificity of 90.4% in Tanzanian patients with suspected acute appendicitis (Kanumba et al., 2011). These discrepancies can be explained by the different weights of the variables in the clinical scores, as reported by Bessoff and Forrester (2020). Several clinical scores such as the AIR (Appendicitis Inflammatory Response) score and the AAS (Adult Appendicitis Score) score cannot be performed in limited resource settings due to the requirement for expensive tests such as C-reactive protein (CRP).

Another important diagnostic issue in LICs is the greater proportion of pediatric patients; this may reduce the sensitivity and specificity of clinical scores (Kulik et al., 2013). A further issue is the wide range of pathogen types that produce disease with symptoms similar to those of acute appendicitis, including Entamoeba, *Ascaris*, *Trichuris trichiura*, *Enterobius vermicularis*, and *Salmonella* Typhi (Chamisa, 2009; Mehndiratta, 2016).

Samuel's Pediatric Appendicitis Score (PAS) appears to be useful in the diagnosis of acute appendicitis in pediatric patients due its lower cost. It can be used in remote areas and LICs. A retrospective observational study demonstrated that at a cut-off of $\geq$8, the specificity of the PAS ranged from 78% to 89% (Scheller et al., 2016).

According to the 2020 WSES guidelines (Di Saverio et al., 2020), a tailored individualized diagnostic approach using a high-probability score may be used to select patients for appendectomy without imaging in LICs, where the availability of imaging diagnostics is limited.

Biochemical markers represent a promising and reliable diagnostic tool for the identification of both negative cases and cases of complicated acute appendicitis in adults. In remote areas, laboratory medical services are often limited due to the lack of availability and the high associated costs (Nkengasong et al., 2018; Wilson et al., 2018).

The timing of diagnosis is essential to prevent a delayed diagnosis, which may lead to worse clinical outcomes, as described widely (Pokharel et al., 2011; Adisa et al., 2012). Geographical factors may explain delays in diagnosis and disparities in outcomes between rural and urban patients, as reported in several studies in Nigeria, Pakistan, and Ethiopia (Adisa et al., 2012; Fahim and Shirjeel, 2005; Hagos, 2014).

In resource-constrained settings, the combination of ultrasound and clinical score are useful in the diagnosis of patients at intermediate risk (Samir et al., 2016; Chada et al., 2017). The overall sensitivity and specificity of ultrasound are 76% and 95%, respectively, as described in a study on point-of-care ultrasonography (POCUS) (2014) (Chang et al., 2014).

Despite computed tomography (CT) of the abdomen has an overall sensitivity of 99% and specificity of 84% in the diagnosis of acute appendicitis, the role of the CT scan in the diagnosis of this condition has been shown to be poor in several studies. In LICs, a CT scan of the abdomen is not suggested. In a study performed at a tertiary hospital in Nigeria, involving more than 1000 cases of acute appendicitis, a CT scan was performed in only one case (Afuwape et al., 2018).

The implementation of ultrasound imaging in LICs may be useful to determine the absence of complicated appendicitis or intraluminal appendicolith. Antibiotic therapy represents a feasible treatment option for imaging-proven uncomplicated appendicitis. Appendectomy remains the treatment of choice for acute appendicitis in LIC populations due to the risk of disease recurrence, diagnostic shortcomings, and delays in escalation of care (Salminen et al., 2018; Podda et al., 2019).

A laparoscopic appendectomy is recommended by several scientific societies; this results in a shorter hospital stay, less pain, a lower incidence of SSI, and lower overall costs (Di Saverio et al., 2020; Gorter et al., 2016; Korndorffer et al., 2010). A diagnostic laparoscopy is cost-effective when compared with ultrasonography and CT and allows the possibility of evaluating the entire abdomen during surgery when the risk of a concurrent pathology may be high (Udwadia, 2004). Laparoscopic appendectomy using cost-saving methods is cost-effective in LICs, as described in several studies, and furthermore it also reduces appendectomy-associated SSI (Adisa et al., 2012; Ruiz-Patiño et al., 2018).

Acute left colonic diverticulitis

Acute sigmoid diverticulitis is a common disease of the Western World and its etiology is strongly related to lifestyle habits, particularly to a high fat diet and alcohol consumption. Recent studies have suggested that the lifetime risk of developing acute left-sided colonic diverticulitis (ALCD) is about 4% among patients with diverticulosis, and up to one-fifth of patients in Western populations with acute diverticulitis are under 50 years of age (Shahedi et al., 2013; Collins and Winter, 2015; Sartelli et al., 2020).

The Clinical Outcomes Research Initiative (CORI) (2009) has reported a prevalence of diverticulosis of 32.6% in patients aged 50–59 years, and the prevalence is increased up to 71.4% in patients aged ≥80 years (Everhart and Ruhl, 2009).

The prevalence of diverticulosis is much lower in Africa and parts of Asia. Early studies from Nigeria noted a low prevalence (1.85%) in 1989. In another study reported in 1992, only 15 individuals out of 26,234 had diverticulosis (Ogunbiyi, 1989; Ihekwaba, 1992). However, data emerging from Africa appear to show an increased prevalence, which appears to be related to the adoption of a Western diet that is low in fiber. A Nigerian study performed in 2016 found a prevalence of diverticulosis of 10.6% (Alatise et al., 2013; Oluyemi and Odeghe, 2016).

Data regarding the prevalence of ALCD in LICs are poor. Clinical findings of patients with ALCD include acute pain or tenderness in the left lower quadrant.

Clinical scores for the diagnosis of acute diverticulitis have been proposed. Laméris et al. (2010) and Andeweg et al. (2011) proposed two clinical scores that include the C-reactive protein (CRP) test. CRP may be useful for the prediction of the clinical severity of acute diverticulitis (Laméris et al., 2010; Andeweg et al., 2011; Kechagias et al., 2014). However, CRP test cost and time are inappropriate for routine use in most LIC settings (Van de Wall et al., 2013; Mäkelä et al., 2015).

As suggested in the WSES guidelines, ultrasound should be performed in the initial evaluation of patients with suspected ALCD, especially in LICs and remote areas (Sartelli et al., 2020). The diagnostic accuracy of ultrasound has been reported, with a sensitivity of 90% and a specificity of 90% (Andeweg et al., 2014).

The CT scan of the abdomen is the gold standard in the diagnosis of ALCD. However, as for the CRP test, the high cost of CT limits its use in resource-constrained settings (Sartelli et al., 2020).

In LICs, the initial evaluation of patients with suspected ALCD should include an accurate clinical examination of the signs and symptoms (a clinical history of one or more previous episodes, localization of symptoms in the lower left abdomen, aggravation of pain on movement, and the absence of vomiting), as well as vital signs.

The choice of treatment for ALCD in LICs is not easy. Antibiotics are not recommended for uncomplicated diverticulitis without signs of systemic inflammation. For patients requiring antibiotic therapy, the WSES guidelines recommend oral administration whenever possible because this may facilitate a shorter inpatient length of stay. Patients with smaller diverticular abscesses may be treated with antibiotics alone. Hartmann's procedure remains useful in the management of diffuse peritonitis in critically ill patients (Sartelli et al., 2017).

Gastrointestinal perforations

In LICs gastrointestinal perforations are caused by several pathologies with different etiopathogenesis and clinical presentations.

Typhoid fever is the most common cause of gastrointestinal perforations in LICs. Typhoid intestinal perforation has a high disease burden in LICs. This disease is rare in countries with good sanitation. Typhoid fever is caused by *Salmonella enterica* (*Salmonella* Typhi and *Salmonella* Paratyphi). The lack of access to medical facilities in remote areas is the cause of the high morbidity and mortality associated with intestinal typhoid (Bhutta, 2006). Typhoid intestinal perforation is more common in children, with a reported mortality that ranges from 4.6% to 39% (GlobalSurg Collaborative, 2018; Seyi-Olajide et al., 2020). The lack of an incidence database and poor financial resources preclude adequate prevention of this public health menace (Ugochukwu et al., 2013).

The most common clinical presentation of enteric perforation is abdominal pain and fever, with perforation typically occurring in the third week of disease (range 24 h to 16 days) (Nuhu et al., 2010; Usang et al., 2009; Ekenze and Ikefuna, 2008). The perforations normally occur in the ileum or jejunum, and less frequently in the colon and gallbladder (Chang et al., 2006).

The major issue with typhoid intestinal perforation is the unavailability of blood and bone marrow culture in most LICs (Archibald and Reller, 2001). The preoperative diagnosis of perforation is usually based on findings of peritonitis in a patient with a history of prolonged febrile illness.

Surgery is recommended in case of typhoid intestinal perforation. Simple excision and closure of small perforations has been reported in up to 88.2% of the cases. Many surgical procedures can be performed: primary closure, excision and closure, resection and primary anastomosis, limited right hemicolectomy, and stoma creation (Sartelli et al., 2013; Meyer et al., 2004).

Abdominal tuberculosis

Tuberculosis (TB) remains prevalent worldwide. Much of the burden is concentrated in high-burden settings in Asia and Africa. The number of TB cases has also been increasing in high-income countries. The most common site of extrapulmonary TB is the ileocecal region and terminal ileum (De Araujo, 2015).

The clinical presentation of TB is variable and non-specific, with non-pathognomonic signs and symptoms. It may mimic other infectious or inflammatory pathological diseases, and even neoplastic conditions (Ara et al., 2005).

Resection of the affected area and anastomosis may be the treatment of choice rather than primary closure in the case of abdominal TB perforation (Sartelli et al., 2017).

Acute calculous cholecystitis

Cholelithiasis is a common disorder all over the world (Ansaloni et al., 2016a). The prevalence in Asia ranges from approximately 3% to 15%. It is nearly non-existent (<5%) in Africa and the prevalence ranges from 4.21% to 11% in China (Sun et al., 2009; Reshetnyak, 2012).

As described in the 2016 WSES guidelines on acute calculous cholecystitis, there is no single clinical or laboratory finding with sufficient diagnostic accuracy to establish or exclude acute cholecystitis. Diagnosis is supported by the combination of detailed history, complete clinical examination, and laboratory tests (Ansaloni et al., 2016).

Clinical features such as right upper quadrant pain, fever, and leukocytosis, along with the findings from relevant imaging studies such as ultrasound are sufficient for diagnosis. Ultrasound is the first-choice imaging investigation for patients with suspected acute cholecystitis due to its relatively low cost, lack of invasiveness, lack of exposure to ionizing radiation, better availability, and high accuracy for gallbladder stones (Kiewiet et al., 2012).

Ultrasound typically shows pericholecystic fluid (fluid around the gall bladder), a distended gall bladder, an edematous gallbladder wall, and gall stones, and Murphy's sign can be elicited on ultrasound examination (Yarmish et al., 2014).

Cholecystectomy is the main treatment option. In acute calculous cholecystitis, surgery is superior to observation. Cholecystectomy shows some cost-effectiveness advantages due to the gallstone-related complications and the high rate of readmission and surgery.

Early cholecystectomy is preferable to delayed cholecystectomy as it results in a shorter recovery time and hospitalization compared to delayed cholecystectomy. Cholecystectomy should

be performed within 10 days of the onset of symptoms. In people with more than 10 days of symptoms, a delayed cholecystectomy after 45 days is better than immediate surgery unless symptoms suggestive of worsening peritonitis or sepsis warrant an emergency surgical intervention (Ansaloni et al., 2016).

Laparoscopic cholecystectomy has largely become the therapy of choice for acute cholecystitis in operable patients. Open cholecystectomy was always considered a feasible option, particularly in LICs or elsewhere in the setting of resource limitations (Afuwape et al., 2012). Laparoscopic cholecystectomy like laparoscopic appendectomy is cost-effective and results in a shorter hospital stay, less pain, and a lower incidence of SSI. Despite several improvements in laparoscopy accessibility in remote areas, too many LICs have reported issues to adopt laparoscopy. The major limitation is the lack of funding to provide sufficient equipment or ancillary staff (Jawale and Jesudian, 2019; Ibn Ouf et al., 2001; Silverstein et al., 2017; Imran et al., 2019). In remote areas, a mini laparotomy cholecystectomy may be a more appropriate option in the resource-constrained rural setting due to its widespread applicability and comparable outcomes to laparoscopic cholecystectomy (Balasubramanian et al., 2018).

Cholecystostomy should be performed as a safe and effective treatment in critically ill patients or in patients with multiple comorbidities unfit for surgery (Peters et al., 2014; Treinen et al., 2015).

Antimicrobial therapy

IAIs are treated with a combination of operative intervention and antibiotics depending on the underlying pathology. The judicious use of antimicrobials is an integral part of good clinical practice. Antimicrobial resistance is a global challenge. No single country can protect itself from the importation of resistant pathogens through travel and trade (Sartelli et al., 2016).

Knowledge of regional/local rates of resistance, when available, should always be an essential component of the clinical decision-making process when deciding on the empirical treatment of infection. Regional epidemiological data and resistance profiles are essential for selecting appropriate antibiotic therapy for IAIs (Kurup et al., 2014; ECDC, 2020).

While high-income countries have extensive surveillance systems to monitor antimicrobial resistance (ECDC, 2020), surveillance systems in LICs have not really been established (Leopold et al., 2014). Data on antimicrobial resistance in LICs have been poorly reported.

The WHO has designed a policy package to combat antimicrobial resistance (2018) to help governments commit to a national plan; however, only a few LICs have initiated one (Leung et al., 2011). An online 'resistance map' has been built by the Center for Disease Dynamics, Economics, and Policy (CDDEP, 2018). The Study for Monitoring Antimicrobial Resistance Trends (SMART) provides the best available evidence for the current status of cIAIs worldwide (Jean et al., 2019).

There is unnecessary or inadvertent use of antibiotics in 20–50% of the cases in acute care models (Schuts et al., 2016).

In LICs, the burden of infectious diseases is exacerbated by limited access to and availability of antibiotics to treat infections. These areas are particularly vulnerable to the economic implications of adverse events related to antibiotics and large-scale antimicrobial resistance (Apalata et al., 2011). The WHO have estimated that only 70% of patients with pneumonia in LICs receive an appropriate antimicrobial therapy (World Health Organization, 2011b).

Nosocomial and hospital-associated infections are reported increasingly in LICs. Common drug-resistant infections in LICs are methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterobacteriaceae* (VRE), and multidrug-resistant gram-negative bacteria, which are most pronounced within intensive care units in LICs (Allegranzi et al., 2011; Zaidi et al., 2005).

Increased antimicrobial resistance has had a devastating impact on LICs and remote areas, particularly involving *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, carbapenem-resistant and third-generation cephalosporin-resistant *Enterobacteriaceae*, vancomycin-resistant *Enterococcus faecium*, MRSA, clarithromycin-resistant *Helicobacter pylori*, and fluoroquinolone-resistant *Campylobacter*, and *Salmonella* spp. The burden of these pathogens highlights all the limitations experienced in remote areas as a result of the lack of adequate diagnostic systems and alternative therapeutic options (World Health Organization, 2017). The highest numbers of lives lost due to drug-resistant infections are predicted to be in LICs (Laxminarayan et al., 2013; Ashley et al., 2017).

To combat this situation, antibiotic surveillance and surgical infection surveillance should be systematically established in LICs using a centralized registry or advanced database tools. The use of antibiotic stewardship programs should be mandatory in remote areas (Berrevoets et al., 2017; Barlam et al., 2016).

Table 1
Recommendations

	Recommendations
Acute appendicitis	• A high-probability score may be used to select patients for appendectomy without imaging • Antibiotic therapy is the recommended treatment option for imaging-proven uncomplicated appendicitis • Appendectomy remains the treatment of choice for acute complicated appendicitis • Laparoscopic appendectomy is recommended by several scientific societies, as it results in a shorter hospital stay, less pain, a lower incidence of surgical site infection, and lower overall costs
Acute left-sided colonic diverticulitis	• The initial evaluation should include an accurate clinical examination of signs and symptoms, as well as vital signs • Ultrasound should be performed in the initial evaluation of patients with suspected ALCD • Patients with smaller diverticular abscesses may be treated with antibiotics alone • Hartmann's procedure remains useful in the management of diffuse peritonitis in critically ill patients
Gastrointestinal perforations	• The diagnosis of perforation is usually based on findings of peritonitis in patients with a history of prolonged febrile illness • Surgery is mandatory in cases of typhoid intestinal perforation
Abdominal tuberculosis	• Resection of the affected area and anastomosis may be the treatment of choice rather than primary closure in the case of abdominal tuberculosis perforation
Acute calculous cholecystitis	• Clinical features and ultrasound findings are sufficient for diagnosis • Early laparoscopic cholecystectomy is the recommended treatment option • Mini laparotomy cholecystectomy may be the more appropriate treatment option in resource-constrained rural settings
Antimicrobial therapy	• Antibiotic surveillance and surgical infection surveillance should be systematically established in LICs • The use of antibiotic stewardship programs should be mandatory in remote areas

ALCD, acute left-sided colonic diverticulitis; LICs, low-income countries.

Conclusions

IAIs are an important cause of morbidity and mortality in remote areas. In LICs and remote areas, standardization in applying the guidelines is mandatory to achieve the correct treatment of IAIs, especially with regard to antibiotic therapy. The cornerstones of effective treatment of IAIs in remote areas include early and accurate diagnosis, prompt resuscitation, early and effective source control, and initiation of appropriate antimicrobial therapy. Promoting standards of care in the management of IAIs in remote areas and LICs should be mandatory to achieve the best treatment choice avoiding unnecessary delays in diagnosis and wrong treatments. Table 1 lists the recommendations.

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Author contributions

All authors participated equally in this research and in the preparation of the manuscript.

Conflict of interest

The authors declare no competing interests.

Author contributions

F.C., S.D.S, F.C., M.S, G.P., and L.A.: conceived and designed the study. M.G., E.B., M.C., A.C.M., F.M.L, F.M.A.Z., and W.L.B: performed the data acquisition, analysis and interpretation of data, drafted the article, revised it critically for important intellectual content, and approved the final version to be submitted. Z.D., R.C, and G.P.F.: performed the data acquisition and drafted the manuscript. W.K., E.E.M., A.L., R.V.M N., I.N., C.A.O., B.S, H.A.S.L., and G.C.V.: designed the study, performed the analysis and interpretation of data, and revised the article critically for important intellectual content. M. G., F.C., I.W., and D.G.W: revised the article critically for important intellectual content. All authors gave final approval of the version to be submitted.

Declaration of Competing Interest

The authors report no declarations of interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ijid.2020.07.046.

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