Intra-abdominal Sepsis in Elderly Persons

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Elderly patients represent a greater percentage of the population now than ever before, with 12.4% of North Americans being >65 years of age. Intra-abdominal illnesses in this population often have different etiologies than those seen in younger populations. Because of a variety of physiologic changes that occur as people age, elderly persons have different sites of infection, may present with vague symptoms and longer histories, are more gravely ill, and, overall, have worse prognoses.

The major causes of intra-abdominal sepsis in elderly persons are reviewed, explanations for the differences in presentation and prognosis are offered, and the treatments of each cause are reviewed.

Individuals aged >65 years constituted 6.2% of the world’s population in 1992 and are expected to constitute >20% by 2050 [1]. In the US 2000 census, persons aged >65 years accounted for 12.4% of the US population, a number that is similarly expected to increase [2]. Elderly persons use >25% of all prescription drugs and are the major recipients of medical interventions. Intraabdominal infections that affect persons aged >65 years are challenging to manage, because the etiology, presentation, severity, and outcome differ from those of younger populations.

Intra-abdominal sepsis, although it affects all age groups, takes a greater toll on the elderly population than it does on younger populations. As individuals age, a variety of physiologic alterations become manifest, many of which affect such vital functions as wound healing, oxygen delivery to tissues, immunosurveillance, and eradication of infection. A loss of physiologic reserve, together with concomitant systemic illness, results in worse outcomes for intra-abdominal sepsis. Less ability to tolerate illness and a relative immunoincompetence affects how and when elderly patients present to health care providers with infections. Nutritional status can be deficient in aged persons because of poor dentition, which renders chewing difficult. Appetite may be decreased as a result of a reduction in the number of taste buds. Thinning of the stomach mucosa, accompanied by a decrease in the amount of enzyme and acid secretion, makes digestion and absorption less efficient.

Aging causes the skin to lose elasticity and blood supply, rendering it fragile and more susceptible to injury and infection. Similarly, the lungs lose their elasticity, resulting in less compliance and recoil. Shallow breathing and hypoventilation of the bases of the lungs are the consequences. A lifetime of inhaling environmental pollutants also causes parenchymal fibrosis, inhibited ciliary action, and greater mucus production. These factors result in diminished oxygenation of the arterial blood and a concomitant reduction in oxygen delivery to peripheral tissues. Peritonitis or postoperative abdominal pain further restricts pulmonary excursion. Chronic lung disease foreshadows nosocomial or ventilator-associated pneumonia in elderly patients who have undergone abdominal operations.

Atherosclerotic changes in the arterial system and increased cross-linking of collagen and connective tissue cause elevated peripheral vascular resistance in older patients. Because of this and other cardiovascular comorbidities, elderly individuals are less able to withstand and have resolution of intra-abdominal sepsis. In addition to affecting coronary circulation—and, hence, systemic blood flow—atherosclerotic processes and either endogenous or vasopressor-induced vasoconstriction impair blood supply uniformly throughout the body, including the cerebral, renal, and splanchnic systems. Among other manifestations, this results in a loss of nephrons, which results in diminished ability to filter blood and concentrate urine. Also, there is a loss of lean body mass as a result of the breakdown of muscle and deposition of fatty tissues throughout the body.

The changes occurring in each organ system in elderly patients deplete physiologic reserves and, consequently, the re-
response to peritonitis while they inhibit the ability to localize, combat, and eradicate infections [3, 4]. This is compounded by the fact that elderly patients are more likely to seek care at the hospital later in the course of infection than are younger patients because of difficulty walking and leaving home, fear of hospitalization, altered symptoms, and decreased ability to appreciate and express symptoms [5–9]. Consequently, overall, the outcome of intra-abdominal sepsis is poorer in older patients than it is in younger patients [10]. The additional morbidity and mortality seen in older patients with intra-abdominal sepsis is calculated using Acute Physiology and Chronic Health Evaluation II scores [11].

All of the aforementioned physiologic changes affect pharmacokinetics (particularly antimicrobial pharmacokinetics) in elderly persons [12]. These consequences present a therapeutic dilemma when elderly patients are treated. Because there is less blood flow to organs, higher concentrations of antimicrobials need to be administered, but the mechanisms for detoxifying the drugs and their metabolites are diminished. Not unexpectedly, the toxicity of antimicrobial agents is greater in elderly patients than it is in younger patients [1].

Elderly patients with intra-abdominal sepsis present to physicians with less acute and delayed symptoms, compared with younger patients. Cooper et al. [3] found that elderly patients present with nausea, vomiting, and fever approximately one-half as often as do younger patients. In addition, the duration of symptoms was more than twice as long. In that study, 14% of patients aged >65 years presented with temperatures of <36°C, compared with only 3% of younger patients, and the mean temperature of elderly patients was significantly lower. Older patients were also more likely than young patients to present with polymorphonuclear lymphocyte counts of <2000 lymphocytes/mm³. With regard to the resolution of infection, the elderly population had an increase of ~50% in the number of days to euthermia and in the length of hospital stay [3].

The spectrum of diseases that cause intra-abdominal sepsis in elderly individuals is different from the spectrum in younger populations (table 1). Also, because of the variety of physiologic and anatomic changes that occur with age, the frequency of each disease changes. In a study of elderly patients by Cooper et al. [3], acute appendicitis and diverticulitis each caused intra-abdominal sepsis in 28% of patients, and cholecystitis and cholangitis each caused 12% of cases; intra-abdominal abscesses were present in 9% of subjects [3]. Other causes of intra-abdominal sepsis in elderly persons, such as volvulus, mesenteric vascular ischemia, and perforation of the colon as a result of obstructing adenocarcinoma, are unusual in the young.

Selected endogenous organisms of the gastrointestinal tract become the predominant pathogens in intra-abdominal sepsis. Escherichia coli and Klebsiella, Enterococcus, Enterobacter, and Pseudomonas species are the predominant Enterobacteriaceae; anaerobes from the Bacteroides fragilis group and streptococci are also common [13, 14]. Extensive data from clinical trials have been accumulated in an attempt to determine the optimal antimicrobials and doses for the management of intra-abdominal sepsis. Although each practitioner prefers his or her own antibiotic regimens, a consensus for intra-abdominal infections was proposed by a committee from the Surgical Infection Society [15]. Listed in its Summary of Proposed Guidelines are many well-studied single and combination therapies useful in the treatment of intra-abdominal infections. Modified guidelines derived from these recommendations are listed in table 2 [15]. These guidelines recommend that, after minimal intra-abdominal contamination (including nonperforated cholecystitis; early, simple appendicitis; or bowel obstruction without perforation), antibiotics should be given for ≈24 h. In patients with documented infection, clinical evidence of persistent infection should be the determining factor when deciding the duration of the antimicrobial course, rather than use of an arbitrary 10-day or 2-week regimen. When the source of the infectious process has been controlled and there is clinical response (as determined by maintenance of an febrile state for 48 h, normal WBC count, absence of abdominal tenderness, and return of peristalsis), the antibiotic regimen may be discontinued as soon as 5 days after initiation. In the high-risk patient (including the elderly patient), recommendations include extending the antimicrobial regimen to cover Enterococcus species, and, in carefully selected high-risk patients, to provide empiric antifungal coverage [15].

Tertiary peritonitis has emerged as a significant problem even among elderly patients who have received seemingly appropriate treatment (both medical and operative) of sepsis. Tertiary peritonitis is defined as the recurrence or persistence of intra-abdominal infection after the receipt of appropriate care. Nathens et al. [16] found that this occurred most often after postoperative peritonitis, pancreatitis, and necrotic bowel. However, it could occur after appendicitis, diverticulitis, and perforated ulcers. In that study, the mortality rate was 63.6%. In comparison with the organisms associated with Table 1. Etiologies of intra-abdominal sepsis.

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Percentage of patients, by age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendicitis</td>
<td>&gt;65 years 61</td>
</tr>
<tr>
<td>Diverticulitis</td>
<td>&gt;65 years 6</td>
</tr>
<tr>
<td>Cholecystitis</td>
<td>&gt;65 years 2</td>
</tr>
<tr>
<td>Cholangitis</td>
<td>&gt;65 years 8</td>
</tr>
<tr>
<td>Intra-abdominal abscess</td>
<td>&gt;65 years 9</td>
</tr>
<tr>
<td>Colon cancer, sigmoid volvus, and mesenteric ischemia</td>
<td>~11</td>
</tr>
</tbody>
</table>

NOTE. Adapted from [3].
Table 2. Guidelines for antimicrobial regimens for treatment of intra-abdominal infection.

<table>
<thead>
<tr>
<th>Level of recommendation</th>
<th>Antimicrobial agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 (no therapy listed has been shown to be superior to another)</td>
<td>Cefoxitin, Cefotetan, Ticarclillin-clavulanate, Piperacillin-tazobactam, Ertapenem, Meropenem, Imipenem-cilastatin, Aminoglycoside with antianaerobe (clindamycin or metronidazole)*</td>
</tr>
<tr>
<td></td>
<td>Cefuroxime with antianaerobe</td>
</tr>
<tr>
<td></td>
<td>Third- or fourth-generation cephalosporin with antianaerobic agent</td>
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<tr>
<td></td>
<td>Aztreonam with clindamycin, Ciprofloxacin with metronidazole</td>
</tr>
<tr>
<td>Level 2 (for patients with more-serious infections)</td>
<td>Piperacillin-tazobactam, Imipenem-cilastatin, Meropenem, Aminoglycoside with antianaerobic agent*</td>
</tr>
</tbody>
</table>

* This agent should be used judiciously and cautiously in elderly patients.

Secondary peritonitis, the most common offending organisms were Enterococcus species, Candida species, and Staphylococcus epidermidis, followed by E. coli, Enterobacter species, B. fragilis, and Pseudomonas species [16].

**ACUTE APPENDICITIS**

Acute appendicitis, as another cause of intra-abdominal sepsis, may have an atypical presentation in elderly patients. These variations render the diagnosis of appendicitis difficult in this population, negatively affecting morbidity and mortality. Delays in diagnosis are more common in the elderly population and probably account for the higher incidences of perforation, generalized peritonitis, and death in this population [17–19].

It has been postulated that changes occur in the appendix as we age, including atrophy of intraluminal lymphoid tissue and thinning of the appendiceal wall, which render the appendix more susceptible to inflammation. Atherosclerosis diminishes the blood supply, the lumen becomes narrowed, and the muscularis becomes fibrotic and laden with fat [20]. Thus, small changes in intraluminal pressure can produce rapid ischemia, gangrene, and perforation at rates that are much quicker in older persons than they are in younger persons. A perforated appendix may present in the older patient as a distal small bowel or right colonic obstruction, and, during surgery, it may have to be distinguished from carcinoma of the cecum.

Plain films of the abdomen show an appendicolith in ~20% of cases of acute appendicitis. When the diagnosis is in question, ultrasonography and CT can be useful. Ultrasonography has been shown to have a sensitivity of 80% and a specificity of 95% [21]. CT is particularly useful for elderly patients who are mentally confused, obese, or immunosuppressed or who lack localized symptoms. The mortality rate for appendicitis in the elderly population is 2%–14%, and morbidity is ~40% [5, 10, 22, 23].

**DIVERTICULITIS**

Diverticula are routinely found in elderly persons. In North America, nearly 25% of patients in their 60s and 40% in their 70s have diverticula [24]. Diagnosis is readily made via CT scan with a water-soluble contrast enema. Older patients are more likely than younger patients to have diverticular perforations that result in generalized, rather than localized, peritonitis [18]. These patients also tend to have a shorter and more rapidly progressive course of disease. Watters et al. [18] found that the mortality rate for persons aged >65 years who had perforation was 17%, compared with 6% for younger patients; the groups were statistically similar with regard to frequency of treatment (with the Hartmann procedure).

The trend toward decreasing length of hospitalization has led to a greater acceptance of primary resection and anas-
tomosis for treatment of left-side colon lesions. Umbach and Dorazio [25] found that the single-stage procedure had an incidence of complications of 30% (compared with 29%–69% morbidity for the Hartmann procedure) with no perioperative mortality. In this series, the most common complications were wound infections (in 9.1% of patients), urinary retention (in 6.1%), and urinary tract infections (in 6.1%). A single patient had an anastomotic leak that required conversion to the Hartmann procedure. Hemodynamic instability, malnourishment, severe anemia, immunosuppression, diffuse peritonitis, and questionable viability of the bowel wall are contraindications for the single-stage operation. A 2-stage procedure should be used in these situations. Unprepared bowel, technical complications, presence of a chronic abscess cavity, and mild anemia, immunosuppression, or malnutrition are relative contraindications for the single-stage operation [26].

In the unusual case of complete sigmoid obstruction that results from severe acute diverticulitis, a first-stage proximal colostomy may be indicated, but this procedure is otherwise rarely used as a definitive treatment. An advancement in treatment of diverticular pericolic abscesses has been percutaneous drainage with staged primary resection and anastomosis after the abscess has resolved. A single-stage resection can be performed in ~70% of patients in stable condition.

CHOLECYSTITIS AND CHOLANGITIS

More than one-half of all people aged >70 years have gallstones [27]. Although most cases are asymptomatic, 20% of older patients have serious complications of their disease, a much higher rate than that seen in the 40–50-year-old age group [28]. E. coli, Klebsiella species, and B. fragilis commonly colonize the gallbladder and biliary tree in elderly patients and are the organisms recovered in secondary complications. Biliary operations have become the most commonly performed abdominal procedure in the elderly population.

Similar to appendicitis and diverticulitis, elderly patients with cholecystitis have delays in presentation to the hospital, diagnosis, and treatment. Morrow et al. [29] estimated a 33% increase in time from onset of symptoms to diagnosis and treatment. They reported that elderly patients presented with a seemingly benign course that was not representative of the severity of illness. In fact, despite a perceived decrease in the severity of illness, 40% of the patients in their study had empyema of the gallbladder, gangrenous cholecystitis, or free perforation, and 15% had subphrenic abscesses or liver involvement. Glenn and McSherry [30] corroborated this finding by showing that severe disease and gangrene can be present with only mild leukocytosis and a lack of peritoneal signs.

As with younger populations, the need for an emergency operation for cholecystitis is associated with a significantly worse outcome. Elderly men are approximately twice as likely to require emergency treatment than are older women (58.9% vs. 32.1%). Associated with this is a 5-fold increase in the incidence of necrotizing, suppurative, or hemorrhagic cholecystitis and a 50% increase in the incidence of complications for patients requiring emergency treatment. Infectious complications include empyema, gangrenous cholecystitis, perforation, abscess formation, and fistula, and the mortality rate is 15%–20% [31, 32] (table 3).

The overall mortality rate for cholecystectomy for all age groups is ~0.5%–1.8% [33, 34]. In the elderly population, it increases to 0.8%–4.4%. If the procedure is performed emergently, the mortality rate for cholecystectomy in the elderly population has a range of 10%–19% [35–41]. With the widespread acceptance of laparoscopic cholecystectomy as the treatment of choice for gallbladder disease, and with the increasing skill with which it is performed, morbidity and mortality associated with cholecystectomy are expected to decrease. Indeed, Massie et al. [42] have shown that significantly fewer complications are associated with laparoscopic cholecystectomy compared with the open approach.

Acute cholangitis is most commonly caused by cholelithiasis, iatrogenic strictures, neoplasms, or sclerosing cholangitis [14]. The classic findings of jaundice, abdominal pain, and fever with chills (Charcot’s triad) are only found in 55%–70% of patients [43]. Common in the elderly population are hypotension and mental confusion—which, with Charcot’s triad, make up Reynold’s pentad. Treatment regimens are based on vigorous fluid rehydration, aggressive monitoring, and nasogastric suction to decrease pancreatic stimulation. Three-quarters of patients who undergo these measures

<table>
<thead>
<tr>
<th>Complication</th>
<th>Percentage of patients</th>
</tr>
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<tbody>
<tr>
<td>Overall</td>
<td>21 37</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>50 34</td>
</tr>
<tr>
<td>Pulmonary</td>
<td>10 19</td>
</tr>
<tr>
<td>Urinary</td>
<td>13 13</td>
</tr>
<tr>
<td>Abscess/sepsis</td>
<td>0 9</td>
</tr>
<tr>
<td>Wound infection</td>
<td>13 6</td>
</tr>
<tr>
<td>Renal failure</td>
<td>7 4</td>
</tr>
<tr>
<td>Pancreatitis</td>
<td>3 2</td>
</tr>
<tr>
<td>Upper gastrointestinal bleeding</td>
<td>3 8</td>
</tr>
<tr>
<td>Fistula</td>
<td>0 2</td>
</tr>
<tr>
<td>Ileus</td>
<td>0 2</td>
</tr>
<tr>
<td>Liver failure</td>
<td>0 2</td>
</tr>
</tbody>
</table>

NOTE. From [13].
will respond within 24–48 h. If they do not respond, patients with extrahepatic ductal dilatation should undergo endoscopic retrograde cholangiopancreatography, and those with only intrahepatic ductal dilatation should undergo percutaneous transhepatic cholangiography. If these measures fail, common bile-duct exploration is required to decompress the biliary system. Overall, the mortality rate for patients with cholangitis is ∼10% [14].

**COLON CANCER PERFORATION**

Approximately 140,000 Americans, the great majority of whom are older than 60 years, develop colon cancer each year. Perforation may occur in advanced tumors, causing peritonitis or abscess, with an incidence range of 2.6%–10% [44, 45]. Chen and Sheen-Chen [46] found that 19% of perforations at the lesion site and 33% proximal to the cancer occurred in elderly patients, despite the fact that elderly patients accounted for ∼15% of the study population. This latter group likely represents proximal perforation from obstructing colon cancers. These findings were corroborated by Kylloinen [47] and Runkel et al. [48].

Crowder and Cohn [44] found that the most common presenting signs and symptoms of colon cancer preceding perforation were abdominal pain (45 of 45 patients), weight loss (32 of 45 patients), anemia (26 of 45 patients), and melena (21 of 45 patients). Approximately 67% of the patients in this study were aged >69 years. Kelley et al. [49] found perforation to be the most deadly complication of colon cancer. In this study, operative mortality was 33%.

After perforation of the sigmoid colon, the postoperative mortality increases substantially, with a range of 16%–38% [47, 50–52]. Peritonitis resulting from perforation has a poorer outcome in elderly patients, with regard to both postoperative recovery and survival from cancer. Possible reasons for the worsened outcomes in this scenario are poorer nutritional status resulting from the cancer, peritoneal spread of the cancer during perforation, more-advanced local disease, and the emergent nature of interventions in less-than-adequately prepared patients. In addition to higher operative mortality and morbidity, these patients have poor 5-year survival rates [46].

**MESENTERIC ISCHEMIA**

Fortunately, mesenteric ischemia is a relatively uncommon cause of acute abdomen in elderly patients, because the mortality rates have a range of 45%–90% [53]. Reasons contributing to this may be delayed diagnosis causing intestinal infarction before initiation of therapy and the irreversibility of bowel ischemia after a few hours. Embolus of the superior mesenteric artery accounts for approximately one-half of cases and results from embolization of a left atrial or ventricular mural thrombus after a period of cardiac infarction, dysrhythmia, or both. Superior mesenteric artery thrombosis accounts for <25% of cases, and, when it occurs, it usually results from progressive atherosclerosis at the superior mesenteric artery origin. Least commonly, mesenteric ischemia can be due to venous thrombosis. This condition is most commonly associated with hypercoagulable states, abdominal trauma, portal hypertension, pancreatitis, viscus perforation, intra-abdominal sepsis, and cancer.

Elderly patients with mesenteric ischemia present with abdominal pain that is out of proportion to the results of the physical examination, bloody diarrhea, and forceful evacuation of stool. Risk factors for this condition include age of >50 years, coronary artery disease, peripheral vascular disease, history of intestinal angina, hypertension, critical illness after an operation, and presence of multiple comorbid conditions. Laboratory evaluations may reveal leukocytosis, hemoconcentration, an elevated alkaline phosphatase level, metabolic acidosis with elevated base deficit, an increased serum lactate level, hyperamylasemia, and hyperphosphatemia. Plain films of the abdomen generally reveal nothing remarkable until later in the course of the condition, when dilated loops of bowel with air-fluid levels, thumbprinting of the bowel wall, intramural or portal venous gas, and free intraperitoneal air can be seen [54].

Initial treatment consists of therapy with intravenous fluids, monitoring with a Swan-Ganz catheter, and urgent mesenteric arteriogram or exploration. Therapy with digitalis or vasopressors should be discontinued, because their use can exacerbate ischemia. Broad-spectrum antibiotics are indicated to control bacterial translocation across the ischemic intestinal wall. When peritoneal signs are present, exploratory laparotomy is indicated. Nonviable bowel must be resected and intestinal blood flow restored.

**SIGMOID VOLVULUS**

Volvulus of the sigmoid colon is 20 times more likely to occur in elderly patients than it is in younger patients. An acquired redundancy of the sigmoid colon over time resulting from a high residual colonic content and dysmotility likely accounts for the increased incidence [55]. Patients with sigmoid volvulus present with colicky abdominal pain, distention, and obstipation. After the bowel becomes strangulated, the elderly patient’s symptoms may progress to generalized abdominal pain, fever, leukocytosis, and hypotension. Plain films of the abdomen show a “bird’s beak” sign pointing to the site of obstruction. If no peritoneal signs are present, decompression using endoscopy should be performed and a rectal tube should be placed. This therapy is successful in >70% of patients [53].
Even when treatment is successful, incidence of recurrent sigmoid volvulus is high (55%–90%), mandating that each patient be evaluated for elective sigmoid colectomy [53]. When peritoneal signs are present, urgent exploratory laparotomy is indicated. The mortality rate approaches 70% when the bowel is gangrenous [53].

**CONCLUSIONS**

Given the increased mortality and morbidity associated with intra-abdominal sepsis in the elderly population, and given the varied means of disease presentation, practitioners must have heightened indices of suspicion when treating these patients. The decrease in the acuity of symptoms and delay in presentation can make diagnosis difficult. Early CT and, to a lesser extent, ultrasonography are both noninvasive ways to achieve rapid, accurate diagnoses. In addition, each offers the ability of appropriate serum levels of nonnephrotoxic antimicrobials are essential preparations for the operation. Surgeons increasingly prefer a single definitive operation over staged procedures in patients who are at suitable risk. These measures, if used judiciously, offer the promise of decreased morbidity and mortality rates in elderly patients with intra-abdominal infections.

**References**

41. Massie MT, Massie LB, Marrangoni AG, et al. Advantages of laparo-