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# Abstract

The CIAO Study is a multicenter observational study currently underway in 66 European medical institutions over the course of a six-month study period (January-June 2012).

This preliminary report overviews the findings of the first half of the study, which includes all data from the first three months of the six-month study period.

Patients with either community-acquired or healthcare-associated complicated intra-abdominal infections (IAIs) were included in the study.

912 patients with a mean age of 54.4 years (range 4–98) were enrolled in the study during the first three-month period. 47.7% of the patients were women and 52.3% were men. Among these patients, 83.3% were affected by community-acquired IAIs while the remaining 16.7% presented with healthcare-associated infections. Intraperitoneal specimens were collected from 64.2% of the enrolled patients, and from these samples, 825 microorganisms were collectively identified.

The overall mortality rate was 6.4% (58/912). According to univariate statistical analysis of the data, critical clinical condition of the patient upon hospital admission (defined by severe sepsis and septic shock) as well as healthcare-associated infections, non-appendicular origin, generalized peritonitis, and serious comorbidities such as malignancy and severe cardiovascular disease were all significant risk factors for patient mortality.

White Blood Cell counts (WBCs) greater than 12,000 or less than 4,000 and core body temperatures exceeding 38°C or less than 36°C by the third post-operative day were statistically significant indicators of patient mortality.


# Introduction

Intra-abdominal infections (IAIs) include a wide spectrum of pathological conditions, ranging from uncomplicated appendicitis to fecal peritonitis.

From a clinical perspective, IAIs are classified in two major categories: complicated and uncomplicated [1].

In the event of a complicated IAI, the infectious process proceeds beyond a singularly affected organ and causes either localized peritonitis (intra-abdominal abscesses) or diffuse peritonitis. Effectively treating patients with complicated intra-abdominal infections involves both source control and antibiotic therapy.

Source control is a broad term encompassing all measures undertaken to eliminate the source of infection and control ongoing contamination [2].

The most common source of infection in community-acquired intra-abdominal infections is the appendix, followed by the colon, and then the stomach. Dehiscence complicates 5–10% of intra-abdominal bowel anastomoses and is associated with an increased mortality rate [3].

Antimicrobial therapy plays an integral role in the management of intra-abdominal infections; empiric antibiotic therapy should be initiated as early as possible.

Bacterial antibiotic resistance has become a very prevalent problem in treating intra-abdominal infections, yet despite this elevated resistance, the pharmaceutical industry has surprisingly few new antimicrobial agents currently in development.

In the last decade, the increased emergence of multidrug-resistant (MDR) bacteria, such as extended-spectrum beta-lactamase (ESBL)-producing *Enterobacteriaceae,* Carbapenem-resistant *Klebsiella pneumoniae*, *Pseudomonas aeruginosa, Acinetobacter baumannii,* Vancomycin-resistant *Enterococcus,* and Methicillin-resistant *Staphylococcus aureus,* has foreshadowed a troubling trend and become an issue of key concern in the medical community regarding the treatment of intra-abdominal infections.

In the specific context of intra-abdominal infections, ESBL-producing *Enterobacteriaceae* pose the greatest resistance-related problem. Today these pathological microorganisms are frequently found in both nosocomial and community-acquired IAIs.

The recent and rapid spread of serine carbapenemases in *Klebsiella pneumoniae* (KPC) has become an important issue concerning antimicrobial therapy in hospitals worldwide and is of primary importance in properly optimizing the use of carbapenems based on a patient's indication and exposure criteria [4].

# Study design

The purpose of the CIAO Study is to describe the epidemiological, clinical, microbiological, and treatment profiles of community-acquired and healthcare-associated complicated intra-abdominal infections (IAIs) based on the data collected over a six-month period (January 2012 to June 2012) from 66 medical institutions (see Figure 1) across Europe. This preliminary report overviews the findings of the first half of the study, which includes all data from the first three months of the six-month study period.

**Figure 1 Geographic distribution of the CIAO study**

Patients with either community-acquired or healthcare-associated complicated intra-abdominal infections (IAIs) were included in the study.

In each treatment center, the center coordinator collects and compiles the data in an online case report database.

The collected data include the following: (i) patient and disease characteristics, i.e. demographic data, type of infection (healthcare- or community-acquired), severity criteria, previous curative antibiotic therapy administered in the seven days preceding surgery; (ii) origin of infection, surgical procedures performed, and antibiotic therapies administered; and (iii) microbiological data, i.e. identification of bacteria and microorganismal pathogens within the peritoneal fluid, the presence of yeasts (if applicable), and the antibiotic susceptibilities of bacterial isolates.

This observational study does not attempt to change or modify the laboratory or clinical practices of the participating physicians or their respective institutions, and neither informed consent nor formal approval by an Ethics Committee is required.

The study will continue to meet and abide by the standards outlined in the Declaration of Helsinki and Good Epidemiological Practices.

A Scientific Committee was established to impartially assess the objectives, methodology, and overall scientific quality of the project.

The study is monitored by the Coordination Center, which investigates and verifies missing or unclear data submited to the central database.

Statistical analyses were performed using MedCalc® statistical software.

# Results

## Patients

912 patients with a mean age of 54.4 years (range 4–98) were enrolled in the study during the first three-month period. 432 patients (47.7%) were women and 480 (52.3%) were men. Among these patients, 753 (83.3%) were affected by community-acquired IAIs while the remaining 159 (16.7%) suffered from healthcare-associated infections. Intraperitoneal specimens were collected from 586 (64.2%) of the enrolled patients.

338 patients (37%) were affected by generalized peritonitis while 574 (63%) suffered from localized peritonitis or abscesses.

123 patients (13.5%) were admitted in critical condition (severe sepsis, septic shock).

Tables 1 and 2 contain the clinical findings and radiological assessments recorded upon patient admission.

**Table 1 Clinical findings**

| Clinical findings | Patients n° (%) |
|---|---|
| Abdominal pain | 102 (11,2%) |
| Abdominal pain, abdominal rigidity | 87 (9,5%) |
| Abdominal pain, abdominal rigidità, T > 38°C or <36°C, WBC >12000 or < 4000 | 38 (4,2%) |
| Abdominal pain, abdominal rigidity, T > 38°C or <36°C, | 184 (20,2) |
| Abdominal pain, abdominal rigidity, WBC >12000 or < 4000 | 182 (20%) |
| Abdominal pain, T > 38°C or <36°C, | 28 (3%) |
| Abdominal pain, T > 38°C or <36°C, WBC >12000 or < 4000 | 100 (11%) |
| Abdominal pain, WBC >12000 or < 4000 | 138 (15,1) |
| T > 38°C or <36°C | 5 (0,5%) |
| T > 38°C or <36°C, WBC >12000 or < 4000 | 22 (2,4%) |
| WBC >12000 or < 4000 | 15 (1,7) |
| Not reported | 11 (1,2%) |

**Table 2 Radiological procedures**

| Radiological procedures | Patients n° (%) |
|---|---|
| Abdomen X ray | 91 (10%) |
| Abdomen X ray, CT | 73 (8%) |
| Abdomen X ray, ultrasound | 167 (18,3%) |
| Abdomen X ray, ultrasound, CT | 88 (9,6%) |
| Abdomen X ray, ultrasound, MRI | 2 (0,2%) |
| CT | 208 (22,8%) |
| Ultrasound | 153 (16,8%) |
| Ultrasound, CT | 74 (8,1%) |
| Ultrasound, CT, MRI | 1 (0,1%) |
| Ultrasound, MRI | 2 (0,2%) |
| Not reported | 53 (5,8%) |

## Source control

The various sources of infection are outlined in Table 3. The most frequent source of infection was acute appendicitis. 350 cases (38.4%) were attributable to this condition.

**Table 3 Source of infection**

| Source of infection | Patients n° (%) |
|---|---|
| Appendicitis | 350 (38,4%) |
| Cholecystitis | 131 (14,4%) |
| Post-operative | 108 (11,8%) |
| Colonic non diverticular perforation | 75 (8,2%) |
| Gastroduodenal perforations | 74 (8,1%) |
| Diverticulitis | 71 (7,8%) |
| Small bowel perforation | 44 (4,8%) |
| Others | 45 (4,9%) |
| PID | 7 (0,8%) |
| Post traumatic perforation | 7 (0,8%) |

108 cases (11.8%) were attributable to post-operative infections. Anastomotic leaks were the most prevalent cause of post-operative infection. Of the patients with post-operative infections, 34.2% resulted from colo-rectal leaks, 15.7% from upper gastro-intestinal leaks, 12% from pancreatic leaks, 11.1% from biliary leaks, and 0.9% from urinary leaks.

The most frequently performed procedure employed to address complicated appendicitis was the open appendectomy. 189 patients (54%) admitted for complicated appendicitis underwent open appendectomies: 135 patients (71.4%) for localized infection or abscesses and 54 patients (28.6%) for generalized peritonitis. A laparoscopic appendectomy was performed on 143 patients (40.8%) presenting with complicated acute appendicitis, 95 and 53 of whom underwent the procedure for localized peritonitis/abscesses and generalized peritonitis, respectively. Open colonic resection was performed on three patients to address complicated appendicitis. In the other 15 cases of complicated appendicitis (4.3%), conservative treatment (percutaneous drainage, surgical drainage, and non-operative treatment) was performed. 2.3%

of patients underwent percutaneous drainage and interval appendectomies to address appendicular abscesses.

The most frequently performed procedure to address cholecystitis was the open cholecystectomy. 66 cholecystitis patients (50.4%) underwent this procedure. A laparoscopic cholecystectomy was performed on 46 patients (35.1%). In the remaining cases, conservative treatment methods (percutaneous drainage, non-operative treatment) were alternatively employed.

The Hartmann resection was the most frequently performed procedure to address complicated diverticulitis. 35 patients (49.3%) underwent a Hartmann resection, and of these resections, the vast majority were open procedures (91% open compared to 9% laparoscopic). 23 of these patients underwent a Hartmann resection for generalized peritonitis, while the remaining 12 underwent the same procedure for localized peritonitis or abscesses.

Colo-rectal resection was performed in 16 cases (22.5%). Contrastingly, laparoscopic resection was performed on only two patients, (one patient with and one patient without protective stoma). Open resection was performed on 14 patients (five with and nine without stoma protection).

The other patients received conservative treatment (percutaneous drainage, non-operative treatment, surgical drainage and stoma). Seven patients (9.9%) underwent laparoscopic drainage.

For patients with gastro-duodenal perforations, the most frequent surgical procedure was gastro-duodenal suture (63 patients). 57 patients underwent open gastro-duodenal suture (85.1%) and six patients underwent laparoscopic gastro-duodenal suture (8.1%). Two (2.7%) patients underwent gastro-duodenal resection. The nine remaining patients (12.2%) received conservative treatment (non-operative treatment, surgical drainage).

Among the 44 patients with small bowel perforations, 35 underwent open small bowel resection (79.5%) and two (4.5%) underwent laparoscopic small bowel resection. The remaining seven patients were treated non-surgically.

Among the 75 patients with colonic non-diverticular perforation, 25 patients (33.3%) underwent open Hartmann resection, 27 (36%) underwent open resection with anastomosis and without stoma protection, and 11 underwent open resection with stoma protection (14.7%).

Source control was effective in 838 patients and ineffective in 57 patients.

## Microbiology

Intraperitoneal specimens were collected from 586 (64.2%) patients.

Intraperitoneal specimens were isolated from 453 of the 753 patients with community-acquired intra-abdominal infections (60.2%).

Among the remaining 159 patients with healthcare-associated intra-abdominal infections, intraperitoneal specimens were collected from 133 patients (83.6%).

The major pathogens involved in intra-abdominal infections were found to be *Enterobacteriaceae.*

The aerobic bacteria identified in samples of peritoneal fluid are reported in Table 4.

**Table 4 Aerobic bacteria in the peritoneal fluids**

| **Total** | **697 (100%)** |
|---|---|
| **Aerobic Gram negative bacteria** | **492 (70,6%)** |
| Escherichia coli | 314 (45%) |
| (Escherichia coli resistant to third generation cephalosporins) | 35 (5%) |
| Klebsiella pneuumoniae | 55 (7,9%) |
| (Klebsiella pneumoniae resistant to third generation cephalosporins) | 19 (2,7%) |
| Enterobacter | 28 (4%) |
| Proteus | 14 (2%) |
| Pseudomonas | 32 (4,6%) |
| Others | 49 (7%) |
| **Aerobic Gram positive bacteria** | **205 (29,7%)** |
| Enterococcus faecalis | 70 (10%) |
| Enterococcus faecium | 31 (4,4%) |
| Staphylococcus Aureus | 22 (3,1%) |
| Streptococcus spp. | 48 (6,9%) |
| Others | 34 (4,9%) |

In community-acquired IAIs, *Escherichia coli* ESBL isolates comprised 8.1% (21/259) of all *Escherichia coli* isolates, while *Klebsiella pneumoniae* ESBL isolates represented 19.3% (6/31) of all *Klebsiella pneumoniae* isolates.

ESBL-positive *Enterobacteriaceae* increased in the group of patients with healthcare-associated infections. *Escherichia coli* ESBL-positive isolates comprised 25.4% (14/55) of all *Escherichia coli* isolates, while *Klebsiella pneumoniae* ESBL isolates made up 54.2% (13/24) of total *Klebsiella pneumoniae* isolates.

There were two isolates of *Klebsiella pneumoniae* that proved to be resistant to Carbapenems. Both of these Carbapenem-resistant *Klebsiella pneumoniae* isolates were acquired in an in-hospital intensive care unit.

Among the identified aerobic gram-negative isolates, there were 32 isolates of *Pseudomonas aeruginosa* (4.6% among aerobic bacteria isolates).

There appeared to be few significant differences between the *Pseudomonas* isolates identified in healthcare-associated and community-acquired infections.

The two *Pseudomonas aeruginosa* strains resistant to carbapenems were also acquired in the intensive care unit.

Among the identified aerobic gram-positive bacteria, *Enterococci* (*E. faecalis and E. faecium*) were identified in 101 cases (14.5% of all aerobic isolates). Eight glycopeptide-

resistant *Enterococci* were isolated (six were glycopeptide-resistant *Enterococcus faecalis* isolates, and two were glycopeptide-resistant *Enterococcus faecium* isolates).

Although Enterococci were also present in community-acquired infections, they were far more prevalent in healthcare-associated infections.

The identified peritoneal isolates from both healthcare-associated and community-acquired IAIs are listed in Table 5.

**Table 5 Aerobic bacteria in community acquired and health-care associated IAIs**

| **Community-acquired IAIs** | **Isolates n°** | **Healthcare associated IAIs** | **Isolates n°** | **P** |
|---|---|---|---|---|
| Aerobic bacteria | 498 (100%) | Aerobic bacteria | 199 (100%) | |
| Escherichia coli | 259 (52,2%) | Escherichia coli | 55 (27,6%) | 0,0002 |
| (Escherichia coli resistant to third generation cephalosporins) | 21 (4,2%) | (Escherichia coli resistant to third generation cephalosporins) | 14 (7%) | NS |
| Klebsiella pneumoniae | 31 (6,2%) | Klebsiella pneumoniae | 24 (12%) | 0,0275 |
| (Klebsiella pneumoniae resistant to third generation cephalosporins) | 6 (1,2%) | (Klebsiella pneumoniae resistant to third generation cephalosporins) | 13 (6,5%) | 0,0005 |
| Pseudomonas | 22 (4,4%) | Pseudomonas | 10 (5%) | NS |
| Enterococcus faecalis | 37 (7,4%) | Enterococcus faecalis | 33 (16,6%) | 0,002 |
| Enterococcus faecium | 17 (3,4%) | Enterococcus faecium | 14 (7%) | NS |

278 patients were tested for anaerobes.

83 different anaerobes were ultimately observed. The most frequently identified anaerobic pathogen was *Bacteroides*. 57 *Bacteroides* isolates were observed during the initial course of the study. Among the *Bacteroides* isolates, there was one Metronidazole-resistant strain.

A complete overview of the identified anaerobic bacteria is reported in Table 6.

**Table 6 Anaerobic bacteria in the peritoneal fluids**

| **Anaerobes** | **83** |
|---|---|
| Bacteroides | 57 (68,7%) |
| (Bacteroides resistant to metronidazole) | 1 (1,2%) |
| Clostridium | 6 (7,2%) |
| (Clostridium resistant to metronidazole) | 1(1,2%) |
| Others | 20 (24%) |

Additionally, there were 45 *Candida* isolates identified among the 825 total isolates (4.7%). 36 were *Candida albicans* and 9 were *Candida non albicans*. Two particular candida isolates (one *Candida albicans* and one *Candida non albicans*) appeared to be fluconazole-resistant (see Table 7).

**Table 7 Candida isolates in the peritoneal fluids**

| Candida | 45 |
|---|---|
| Candida albicans | 36 (80%) |
| (Candida albicans resistant to fluconazole) | 1 (2,2%) |
| Non albicans Candida | 9 (20%) |
| (non albicans Candida resistant to fluconazole) | 1 (2,2%) |

The prevalence of Candida was noticeably elevated in the healthcare-associated IAI group (232 total isolates). 25 Candida isolates (10.8%) were observed in this group compared to 20 Candida isolates (3.4%) in the community-acquired IAI group (593 total isolates).

## Outcome

The overall mortality rate was 6.4% (58/912).

232 patients (25.4%) were admitted to the intensive care unit in the early recovery phase immediately following surgery.

87 patients (9.5%) ultimately required a subsequent “re-operation.” 72,4% of these re-laparotomies were “on-demand” follow-up procedures that came about unexpectedly and 19,5% were planned re-operations. Overall, 8% of these patients underwent an “open abdomen” procedure.

The median post-operative day for a subsequent re-operation in the “open abdomen” group was 3.7 days (range 2–5).

According to univariate statistical analysis (see Table 8), a critical clinical condition (severe sepsis and septic shock) upon hospital admission was the most significant risk factor for death; indeed, the rate of patient mortality was 31.7% (40/126) among critically ill patients (patients presenting with septic shock and severe sepsis upon admission), while the mortality rate was only 2.2% (18/786) for clinically stable patients ($p < 0.0001$).

**Table 8 Risk factors for death during hospitalization**

| Risk Factors | Mortality rate in patients with risk factor | Mortality rate in patients without risk factor | P |
|---|---|---|---|
| Critical ill condition at the admission (Severe sepsis, septic shock) | 31,7% (40/126) | 2,2% (18/786) | <0,0001 |
| Healthcare-associated infection | 12,9% (20/155) | 5% (38/757) | 0,0015 |
| Non-appendicular origin | 10,1% (57/562) | (0,3%) 1/350 | <0,0001 |
| Generalized peritonitis | 12,4% (42/338) | 2,8% (16/574) | <0,0001 |
| Delay in the initial intervention (>24 hours) | 11% (29/263) | 4,5% (29/643) | 0,0013 |
| *Comorbidity* | | | |
| Malignancy | 13,8% (21/152) | 4,9% (37/760) | 0,0003 |
| Serious cardiovascular disease | 17,4% (25/144) | 3,6% (28/768) | <0,0001 |

For patients with healthcare-associated and community-acquired infections, the mortality rates were 12.9% (20/155) and 5% (38/757), respectively ($p = 0.0015$).

The mortality rate was 12.4% (42/338) for patients with generalized peritonitis and only 2.8% (16/574) for patients with localized peritonitis or abscesses ($p < 0.001$).

The mortality rate was 10.1% (57/562) for patients with infections of non-appendicular origin and only 0,3% (1/350) for patients with infections of appendicular origin ($p < 0.001$).

Malignancy and serious cardiovascular disease were the most significant comorbidities associated with an elevated mortality rate. For those patients affected by malignancy, the mortality rate was 13.8% (21/152), marking a substantial increase from the 4.9% mortality rate (37/760) for patients who did not suffer from malignancy ($p = 0.0003$).

Similarly, the mortality rates for patients with and without serious cardiovascular disease were 17.4% (25/144) and 3.6%, respectively (28/768) ($p < 0.0001$).

Mortality rates did not vary to a statistically significant degree between patients who received adequate source control and those who did not. However, for patients with a delayed initial intervention (a delay exceeding 24 hours) mortality was 11% (29/263), while, for patients with prompt initial intervention, the mortality rate was only 4.5% (29/643) ($p = 0.0013$).

Patients presenting with a WBC count greater than 12,000 or less than 4,000 and core body temperatures greater than 38°C or less than 36°C by the third post-operative day demonstrated an increased likelihood of patient mortality (see Table 9).

**Table 9 Predictive factors for death during hospitalization**

| Predictive factors | Mortality rate in patients with predictive factors | Mortality rate in patients without predictive factors | P |
|---|---|---|---|
| WBC > 12000 or < 4000 (post-operative day 3) | 24% (39/163), | 2,6% (19/720) | <0,0001 |
| T > 38°C or < 36°C (post-operative day 3) | 12,3% (19/155) | 5,3% (39/728) | 0,0066 |

For operated patients with a WBC count greater than 12,000 or less than 4,000 by post-operative day 3, the mortality rate was elevated to 24% (39/163), while this rate remained at 2.6% (19/720) for patients with a normal WBC count by the third post-operative day ($p < 0.0001$). In patients with core body temperatures exceeding 38°C or less than 36°C by the third post-operative day, the mortality rate was elevated to 12.3% (19/155) while it remained at 5.3% (39/728) for patients exhibiting normal core body temperatures ($p = 0.0066$).

# Discussion

Complicated intra-abdominal infections are an important cause of morbidity and are frequently associated with poor clinical prognoses, particularly for patients in high-risk categories.

Source control encompasses all measures undertaken to eliminate the source of infection and control ongoing contamination.

In recent years, the medical community has debated the proper surgical management of complicated intra-abdominal infections.

Acute appendicitis is the most common intra-abdominal condition requiring emergency surgery. However, this preliminary report has demonstrated that complicated appendicitis is also a frequent source of intra-abdominal infection. The laparoscopic appendectomy is a safe and effective means of surgical treatment for addressing complicated intra-abdominal infections, but open surgery still retains many clinical advantages, including a reduced probability of post-operative intra-abdominal abscesses [5].

In patients with periappendiceal abscesses, the proper course of surgical treatment remains a point of contention in the medical community; however, this contention notwithstanding, the most commonly employed treatment appears to be drainage with subsequent appendectomy [6].

CIAO Study data indicate that the open approach was used in 54% of complicated appendicitis cases while the laparoscopic approach was favored and performed on 40.8% of complicated appendicitis patients. Eight patients underwent percutaneous drainage and interval appendectomies.

The laparoscopic versus open cholecystectomy debate has been extensively investigated in recent years. In the CIAO Study, the open cholecystectomy was the most frequently performed procedure for addressing cholecystitis. 50.4% and 31.5% of cholecystitis patients underwent the open and laparoscopic procedures, respectively.

The optimal surgical management of colonic diverticular disease complicated by peritonitis remains a controversial issue in the medical community.

Hartmann’s resection has historically been considered the procedure of choice for patients with generalized peritonitis and continues to be a safe and reliable technique for performing an emergency colectomy in the event of perforated diverticulitis, particularly in elderly patients with multiple co-morbidities [7-9].

More recently, some reports have suggested that primary resection and anastomosis is the preferred approach to addressing diverticulitis, even in the presence of diffuse peritonitis [10-13].

According to the preliminary CIAO Study data, the Hartmann resection was the most frequently employed procedure for treating complicated diverticulitis. 49.3% of patients underwent this surgical resection. Among the 35 enrolled patients who had undergone a Hartmann resection, 23 patients presented with generalized peritonitis and 12 presented with localized peritonitis or abscesses. 22.5% of patients underwent colo-rectal resection to address complicated diverticulitis.

The significance of microbiological workups of infected peritoneal fluid taken from community-acquired intra-abdominal infections has been debated in recent years.

Since the causative pathogens are often accurately predicted in low-risk patients with community-acquired IAIs, some researchers believe bacteriological diagnosis to be superfluous for these patients. The lack of clinical relevance of many bacteriological cultures

has been readily documented, especially in appendicitis cases in which the etiological agents causing the peritonitis are easily predicted [14]. Other researchers assert that bacteriological diagnosis is still important for low-risk patients with community-acquired IAIs primarily because it may be of value in detecting epidemiological changes in the resistance patterns of pathogens associated with these infections and in better assessing follow-up antibiotic therapy. In higher risk patients with community-acquired IAIs and healthcare-associated IAIs, cultures from the site of infection should always be always obtained.

According to the preliminary CIAO Study data, intraperitoneal specimens were collected from the 64.2% of enrolled patients; these samples were obtained from 60.2% of patients with community-acquired intra-abdominal infections and 83.9% of patients with healthcare-associated intra-abdominal infections.

Routine susceptibility testing for anaerobic organisms continues to prove difficult for many laboratories given a variety of economic and logistical constraints; most clinical laboratories do not routinely determine the species of the organism or test the susceptibilities of anaerobic isolates [15].

CIAO Study data indicate that 44.7% of patients were tested for the presence of aerobic microorganisms.

The major pathogens involved in community-acquired intra-abdominal infections are *Enterobacteriaceae, Streptococcus sp*ecies, and certain anaerobes (particularly *B. fragilis*). Compared to community-acquired infections, healthcare-associated infections typically involved a broader spectrum of microorganisms, encompassing ESBL-producing *Enterobacteriaceae, Enterococcus, Pseudomonas,* and *Candida* species in addition to the *Enterobacteriaceae, Streptococcus species,* and anaerobes typically observed in community-acquired IAIs.

The threat of antimicrobial resistance has become a major challenge in the management of intra-abdominal infections.

The main resistance threat is posed by ESBL-producing Enterobacteriaceae, which are frequently found in community-acquired infections.

According to the study's preliminary findings, ESBL producers were the most prevalent and commonly identified drug-resistant microorganism.

Two isolates of *Klebsiella pneumoniae* appeared to be resistant to Carbapenems. These particular infections were acquired in the intensive care unit.

The rate of *Pseudomonas aeruginosa* among aerobic isolates was 4.6%. There was no statistically significant difference in the *Pseudomonas* appearance rate between community-acquired and healthcare-associated IAIs.

Enterococci (*E. faecalis and E. faecium*) were identified in 14.5% of all aerobic isolates.

Although Enterococci were also present in community-acquired infections, they were far more prevalent in healthcare-associated infections.

Data currently available in mainstream literature regarding the infectious trends of *Candida* species are rather contradictory [16].

In the first half of the CIAO Study, 45 *Candida* isolates (5.7%) were observed among a total of 825 isolates. *Candida* prevalence was significantly higher in the healthcare-associated IAI group than it was in the community-acquired IAI group.

Of the 912 patients enrolled in the study, there were 58 deaths (6.4%).

According to univariate statistical analysis of the data, critical clinical condition of the patient upon hospital admission (defined by severe sepsis and septic shock) as well as healthcare-associated infections, non-appendicular origin, generalized peritonitis, and serious comorbidities such as malignancy and severe cardiovascular disease were all significant risk factors for patient mortality. WBCs greater than 12,000 or less than 4,000 and core body temperatures greater than 38°C or less than 36°C by the third post-operative day were statistically significant indicators of patient mortality.

# Conclusion

Complicated intra-abdominal infections remain an important cause of morbidity with poor clinical prognoses.

The purpose of the CIAO Study is to describe the epidemiological, clinical, microbiological, and treatment profiles of both community-acquired and healthcare-acquired complicated intra-abdominal infections (IAIs) based on the data collected over a six-month period (January 2012 to June 2012) from 66 medical institutions.

The final results of the CIAO Study will be published following the conclusion of the study period in June 2012.

# Competing interests

The authors declare that they have no competing interests.

# Authors' contributions

MS designed the study and wrote the manuscript. FC, LA, AL, KT, HVG, DVL, PV and CDW participated in study design. DVL revised the manuscript. All authors read and approved the final manuscript.

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Figure 1