Original Article

Evaluation of intraoperative peritoneal lavage with super-oxidized solution and normal saline in acute peritonitis

Pankaj K. Garg, Ashwani Kumar, Vijay K. Sharda, Ashok Saini, Arun Garg, Amit Sandhu

Department of Surgery, Government Medical College and Rajindra Hospital, Patiala, Punjab, India

ABSTRACT

Background: The fundamentals in the treatment of acute peritonitis include resuscitation, treatment of septicemia, control of the contaminating source and peritoneal toilet. Numerous studies have shown the roles of different solutions such as normal saline, antibiotics and betadine as intraperitoneal lavage, in reducing morbidity and mortality of peritonitis. The objective of this study was to present our findings on the role of intraperitoneal lavage with normal saline and normal saline followed by super-oxidized solution in patients with acute peritonitis.

Materials and Methods: The patients were randomly allotted by slip method into two groups of 50 each. In the control group, after the definitive surgery for the pathology of peritonitis, the peritoneal cavity was lavaged with normal saline and closed after putting drains. In the study group, after the definitive surgery the peritoneal cavity was lavaged with saline followed by 100 ml of super-oxidized solution and drains were closed for 1 h after abdominal closure. The patients were followed-up for morbidity and mortality.

Results: Surgical site infection (SSI) was present in 27 out of 100 cases in both groups. In the study group, out of 7 infected cases, intraperitoneal fluid cultures were positive in 6 cases, but only 3 had positive swab cultures. In the control group, out of 20 infected cases, swab culture was positive in 16 cases ($p = 0.0399$). Among the study group, bowel sounds return in 4.10 ± 1.20 days compared to 5.9 ± 1.17 in the control group. In the study group, fever >100°F developed in 14 (28%) patients in the post-operative period whereas in the control group it was 29 (58%) ($p < 0.0024$). SSI rates in the two groups were (7/50) 14% and (20/50) 40% respectively ($p = 0.0034$).

Conclusion: This study suggests that super-oxidized solution is effective and safe in reducing post-operative complications including SSI, burst abdomen and episodes of post-operative fever.

Key words: Intraoperative lavage, normal saline, peritonitis, super-oxidized solution, surgical site infection

Introduction

Intra-abdominal sepsis is associated with high morbidity and mortality. In cases of severe intra-abdominal sepsis arising from perforated peptic ulcer, typhoid fever, appendix and other causes of gangrenous gut, there is a high rate of surgical site infection (SSI) in spite of the use of potent antibiotics. Surgeons are able to reduce systemic infection, but SSI remains a challenge where incidence still may be as high as 60-70%.[1] The basic fundamentals in the treatment of peritoneal contamination include general resuscitation measures, treatment of septicemia, control of the contaminating source and peritoneal toilet. While, the first three measures are unanimously agreed upon, peritoneal toilet is a subject of conflicting opinions. Peritoneal lavage is supposed to assist the host, namely the peritoneal defense mechanism, to combat the offending bacteria and contaminating adjuvant, such as blood, bile and other particulate matter.[2]

The instillation of crystalloid solutions into the peritoneal cavity during the laparotomy is a routine practice for many surgeons.[3] A study by Ahrenholz has shown that

Address for correspondence: Dr. Pankaj Kumar Garg, Department of Surgery, Government Medical College & Rajindra Hospital, Patiala - 147 001, Punjab, India.
E-mail: pankajgarg_dr@hotmail.com

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irrigation with these solutions not only dilute bacterial mass, but also impair bacterial phagocytosis because of dilution of defensive proteins like opsonins.[4] Several other studies also support the idea that intraoperative irrigation with normal saline, in the absence of other antimicrobial substance, have no beneficial effect.[5,6] The role of antimicrobial agents such as kanamycin, metronidazole and povidone iodine in intraoperative peritoneal lavage (IOPL) was proved to be non-effective by some authors.[5,7]

Recently, some studies have recommended the use of super-oxidized solution with normal saline for irrigation in cases of intra-peritonel sepsis that it has synergetic effect on patient outcome.[8,9] Super-oxidized solutions are neutral pH, hypotonic solutions with a controlled amount of reactive species and low chlorine content. Its antiseptic properties are due to its reactive species of oxygen and chlorine. These reactive species create an unbalanced osmolarity so that it damages the integrity of the cell membrane, then react and denature the lipids and proteins of single cell organisms. This is because of a direct result of the osmolarity difference between the ion concentrations of the solution and single cell organisms. Multicellular organisms are not prone to such osmolarity changes, therefore, host tissues are spared.[10]

Super-oxidized solutions have been used in humans for cleansing of ulcers, mediastinal irrigation, peritoneal lavage and hand washing.[9,11-13] This study was conducted to evaluate the role of super-oxidized solution and normal saline in cases of peritonitis.

Materials and Methods

This study was conducted on patients who had exploratory laparotomy for peritonitis at Rajindra Hospital, Patiala from January 2011 to June 2012. Hundred patients were included in this study. On the basis of prepared paper slips, these cases were randomly allocated in the control group and study group consisting of 50 cases each.

Only those patients who were found to have peritonitis on exploratory laparotomy were included in the study. Patients with evidence of enteric encephalopathy, liver diseases, renal diseases, history of steroid intake, heart disease and known allergy to any substance with diagnosis of peritonitis were excluded from the study.

After proper and detailed clinical history, patients were examined for signs of peritonitis and investigated for confirmation of peritonitis. After proper resuscitation of patients with *intravenous* fluids, all patients were subjected to exploratory laparotomy. At the time of operation, a sample of peritoneal fluid was collected in a sterile culture vial and transported to Microbiology Department for isolation and identification of the organism and their sensitivity to antibiotics.

- Characteristics of fluid were noted (purulent/serous), color.
- Site, size and number of perforations were noted.
- Any other associated pathology was noted.
- Operative procedure was carried out.

After the definitive surgery, patients were randomly put into two groups.

Control group

In this group, after doing definitive surgery for pathology the peritoneal cavity was washed with 2 l of saline. Then the abdominal cavity was closed after putting in drains.

Study group

In the study group, after definitive surgery for pathology, the peritoneal cavity was washed with 2 l of saline. Then 100 ml of super-oxidized solution was put in the peritoneal cavity and the abdomen was closed after putting drains. The drains were clamped for 1 h so that the super-oxidized solution did not escape. The super-oxidized solution was manufactured and marketed in India by ALKEM Laboratories Ltd. as "OXUM" under the license of Oculus Innovative Sciences, California, USA.

Post-operative course

- The antibiotics given post-operatively were the same in all patients, i.e., ceftriaxone (1.5 g twice a day intravenously for 7 days), gentamycin (80 mg twice a day intravenously for 5 days), metronidazole (400 mg thrice a day intravenously for 5 days).
- The wound was primarily dressed with sterile surgical gauze and covered with occlusive adherent bandage. The primary dressing was removed after 24 h and daily dressing was carried out with povidone-iodine solution. The wound was inspected for signs of infection (sinus formation, seroma formation and pus formation) and dehiscence before each dressing. Secondary suturing was performed after control of infection.
- Swab cultures from the wound were sent for microbiological culture and antibiotic sensitivity if any signs of infection ware present. Patients were then put on antibiotics according to the culture and sensitivity report if they showed any sign of SSI.
- Drain output was monitored daily; amount and also its character (serous/purulent). The drains were removed when output was <50 ml daily and serous. Day of drain removal was noted. If two drains were present then day

of removal of both drains was noted separately.
- Return of bowel sound was noted and observed by hearing 3-4 bowel sounds/min by stethoscope just right to the umbilicus.
- In the post-operative period, fever if present and its duration were recorded. Total leucocytes count and deferential leucocytes count were also noted.
- Number of days for which the patient stayed in the hospital was recorded.
- Stitches were removed on 10th post-operative day.

Statistical analysis

The two groups were compared and the data collected were entered and tabulated using Microsoft Office Excel and analysed using appropriate statistical tests.

Results

Table 1 shows that majority of the patients (71%) in both groups were 18-50 years of age with a mean age of 45.28 years. The mean age was 46.6 ± 14.67 and 43.9 ± 13.57 years respectively in the study and control group. Twenty six patients (52%) were in the 3rd and 4th decades of life in the study group, whereas 28 patients (56%) were in the 3rd and 4th decade of life in the control group. Majority of the patients were males (71/100). In both groups, 41 patients (68.3%) were males and 19 patients (31.7%) were females. Male to female ratio in our study was 2.4:1.

Table 1: Distribution of patients according to age and gender in both groups

Demographic factor	No. of patients in the study group (%)	No. of patients in the control group (%)	Combined
Age			
18-30	12 (24)	14 (28)	26
31-40	14 (28)	14 (28)	28
41-50	7 (14)	10 (20)	17
51-60	6 (12)	7 (14)	13
>60	11 (22)	5 (10)	16
Gender			
Male	33 (66)	38 (76)	71
Female	17 (34)	12 (24)	29

Table 3: Prevalence of wound infection and burst abdomen in the study and control groups

Complication	Study group (%)	Control group (%)	Statistic
Wound infection			
Absent	43 (86)	30 (60)	χ^2=8.574, *P*=0.0034
Present	7 (14)	20 (40)	
Burst abdomen			
Absent	48 (96)	42 (84)	χ^2=5.005, *p*=0.0253
Present	2 (4)	8 (16)	

Table 2 shows that in both groups, the most common site of perforation was the ileum (34%), followed by duodenum (23%) and stomach (15%). The least common site was colon in the study group and appendicular in the control group. Ileal perforation was mainly due to enteric fever and in six cases it was caused by trauma. Duodenal and gastric perforations were complications of peptic ulcer. 10 patients had peritonitis without perforation. They had pus collection in the abdominal cavity. 10 patients had jejunal perforation, which was due to trauma in 7 patients and in 3 patients it was non-specific. Appendiceal perforation was the sequel of acute appendicitis. There were 3 cases of colon perforation, 1 was sigmoid and 1 was descending colon perforations, both were due to trauma. One case of ascending colon perforation was spontaneous.

Table 3 shows that superficial SSI rate was higher in the control group (40%) compared to study group (14%). The difference was statistically significant (*p* 0.003). On analyzing SSI rates in different types of perforations, there was no difference except in gastric and duodenal perforations, which is statistically significant. Burst abdomen was present in 2 cases in the study group and 8 cases of the control. This difference is statistically significant with *p* value 0.025. Post-operative fever occurred in 14 patients in the study group compared to 29 patients in the control group (*p*= 0.0024) [Table 4]. In the study group, only 12 (24%) patients had purulent discharge

Table 2: Distribution of patients according to the site of perforation in two groups

Site of perforation	Study group	Control group	Combined
Duodenal perforation	14	9	23
Gastric perforation	8	7	15
Ileal perforation	14	20	34
Jejunal perforation	5	5	10
Appendicular perforation	3	2	5
Colon perforation	1	2	3
Perforation not found (primary peritonitis)	5	5	10
Total	50	50	100

Table 4: Distribution of patients according to post-operative fever in two groups (χ^2=9.180, *P*=0.0024)

Site of perforation	Study group		Control group		Combined
	<100°F	>100°F	<100°F	>100°F	
Ileal perforation	9	5	8	12	34
Duodenal perforation	10	4	6	3	23
Gastric perforation	5	3	2	5	15
Primary peritonitis	5	0	2	3	10
Jejunal perforation	4	1	1	4	10
Appendicular perforation	2	1	1	1	5
Colon perforation	1	0	1	1	3
Total (%)	36 (72)	14 (28)	21 (42)	29 (58)	100

through drains compared to 26 (52%) in the control group (p=0.0039).

Among the study group, the mean day of appearance of bowel sounds was 4.10 ± 1.20, but among the control group it was 5.9 ± 1.17 ($t = 7.5943$, $p < 0.0001$). The mean day of drain removal among the study group was 5.91 ± 0.99 compared 6.9 ± 0.89 in the control group. The difference was statistically significant.

Swab for culture and sensitivity was taken in all patients having SSI. In the study group, out of 7 infected cases, intraperitoneal fluid culture was positive in 6 cases, only 3 came positive in swab culture post-operatively. In the control group, out of 20 infected cases, swab culture was positive in 16 cases ($p = 0.0399$). The mean duration of hospital stay was similar in the two groups, 13.27 days and 13.73 days for the study and control groups respectively. Eight (16%) patients in the control group compared to 2 (4%) patients in the study group died in our study. Overall mortality rate was 10%.

Discussion

This prospective, randomized trial was undertaken to study and compare the effect of super-oxidized solution and normal saline lavage on SSI and patient outcomes following peritonitis. The study was conducted on 100 patients with diagnosis of peritonitis, undergoing laparotomy. The patients were divided into two groups randomly. The study group consisted of 50 patients who had peritoneal lavage with 100 ml super-oxidized solution after saline lavage and control group comprised of 50 patients who had no further lavage after saline. Both groups were comparable in terms of age and gender.

Most common site of perforation was ileum followed by duodenum and stomach in both groups. So, both groups are comparable on the bases of the site of perforation. These findings are also comparable with various studies.[1,14-17]

In our study, 90% of the patients in the study group and 94% of patients in the control group showed positive cultures. Alam *et al.*, in found 74.5% positive cultures, which is nearly the same as our findings.[18] The most common organism in both groups was *Escherichia coli* in our study (34 cultures in the study and 27 in the control group). Desa *et al.*[19] in found the most common organisms to be *E. coli* and *Klebsiella*.

Post-operatively, swabs culture and sensitivity were taken in all patients who had wound infection. In the study group, out of 7 infected cases, intraperitoneal fluid cultures were positive in 6 cases, but only 3 came positive in swab culture. In the control group, out of 20 infected cases, swab culture was positive in 16 cases. This difference was found to be statistically significant ($p = 0.0399$). This shows that super-oxidized solution is very effective in reducing intraperitoneal contamination. This fact is also supported by a study carried out by Khan *et al.*[8] in the year 2009 who showed that super-oxidized solution caused a reduction in bacterial load ($t = 2.7$, $p < 0.05$).

Silaev[20] treated faecal peritonitis with lavage by a mixture of penicillin and streptomycin. He reported improved survival when antibiotic was used intraperitoneally. Artz *et al.*[21] in a dog model of fecal peritonitis found improved survival when intraperitoneal antibiotic was used. Caridis *et al.*[22] in 1968 in a rat model, in which he produced fecal peritonitis found 30% mortality when intraperitoneal antibiotic was used as compared with 100% mortality when it was not used. Schein *et al.*[2] found no significant difference in mortality of patients treated with or without intraperitoneal lavage with chloramphenicol. Rambo[23] also found no difference in the number of deaths when intraperitoneal irrigation with antibiotic (cephalothin) was used. On the contrary, McKenna *et al.*[24] and Bhushan *et al.*[25] found a significant reduction in mortality in patients treated with antibiotic lavage. This decreased mortality in the study group compared to control group in feco-purulent peritonitis can be explained by the property of super-oxidized solution to decrease infection rate. On comparison with above mentioned studies, we found that super-oxidized solution is superior to intraperitoneal antibiotic lavage. This can be explained by development of better and strong antibiotics for the post-operative course in the present era.

The mean day of drain removal among the study group was 5.91 ± 1.91, but among the control group it was 7.01 ± 2.79. This difference was statistically significant ($t = 2.0$, $p < 0.05$). As super-oxidized solution significantly reduced infection rate and purulent discharge, so the time period for which a drain was kept post-operatively was reduced. This led to early mobility of patients and decreased morbidity.

Among the study group the mean day of appearance of bowel sounds was 4.10 ± 1.20, but among the control group it was 5.9 ± 1.17. This difference was statistically significant ($t = 7.5943$, $p < 0.0001$). Decreased infection rate, decreased purulent discharge from the drain and early removal of drain in the study group explains early appearance of bowel sounds. This led to early break of nil per oral and improvement in morbidity and mortality rate. In the study group, there was an appearance of

fever >100°F in 14 (28%) patients in the post-operative period whereas in the control group it was 29 (58%). This difference was statistically significant ($\chi^2 = 9.180$, $p < 0.0024$). This can be explained by the property of super-oxidized solution to reduce intraperitoneal infection and better wound healing.

Wound infection rates in the two groups were (7/50) 14% and (20/50) 40% respectively, which was found to be statistically significant ($p = 0.0034$). The overall wound infection rate was 27%. Burst abdomen occurred in 2 (4%) cases in the study group and in 8 (16%) cases in the control group. Wound infection was the commonest complication reported by Bhansali[26] and Kaul[27] when they studied the effectiveness of various irrigating solutions in reducing the incidence of wound infection in deep experimental wounds in guinea pigs. They found that irrigation with saline and clorpactin solutions reduced the incidence by 50% while identical treatment with 1% neomycin reduced it by 97%. Noon *et al.*[28] found a reduction in wound infection when antibiotic (neomycin and bacitracin) was used with saline. Bhushan *et al.*[25] found increased evidence of wound dehiscence in the control group (30%) than in the study group (23.3%). Fowler[29] in patients of complicated appendicitis found no benefit on the incidence of wound infection when post-operative intraperitoneal lavage was used. Stewart and Matheson[30] in cases of appendicular peritonitis found a reduction in the number of wound infections when tetracycline was used intraperitoneally. Nomikos *et al.*[31] found that IOPL with chloramphenicol resulted in significantly better results of wound infection than were achieved with saline alone. On the contrary, Schein *et al.*[2] found no significant difference when IOPL was done with chloramphenicol. Alam *et al.*[18] in reported the incidence of infection as 35.7%.

On comparison of wound infection in different types of perforation, we concluded that in upper *gastrointestinal* (GI) perforations, which are less contaminated wound infection rate significantly decreased with super-oxidized solution (gastric $p = 0.0384$, duodenal $p = 0.0358$) while in lower GI perforations, which are more contaminated, wound infection rate decreased in the study group, but this is not statistically significant. This may be due to less amount of super-oxidized solution (100 ml) being used. Burst abdomen was found in 10% cases in a study conducted by Khanna and Mishra[32] in 1984, which was much higher compared to the overall incidence in our study (1.67%). Thus, we can safely conclude that super-oxidized solution is effective in reducing wound infection rate and burst abdomen in acute peritonitis.

Total hospital stay in the study group was 13.27 days and in the control group was 13.73 days. This shows that the hospital stay was reduced slightly when super-oxidized solution was used, but not to statistically significant levels. Bhushan *et al.*[25] found decreased hospital stay when post-operatively intraperitoneal antibiotic was used as a lavage solution. In his study, the average hospital-stay in the study group was 15.02 days, whereas it was 17.86 days in the control group. On the contrary, Vallance and Waldron[33] found no improvement in the duration of hospital stay of patients treated with intraperitoneal lavage with chlorhexidine gluconate or povidone iodine when compared with those who received only saline lavage. Hospital stay in India is dependent on various factors. Most of the patients come from remote villages where tertiary hospital facilities are not available, so they prefer to stay in the hospital for a longer time.

Conclusion

We found that SSI was higher in the control group compared to the study group while removal of drain took longer time in the control group as compared to study group. Burst abdomen was present in 2 cases in the study group compared with 8 cases of the control. With these results, this study shows that super-oxidized solution is effective and safe in reducing post-operative complications such as SSI and burst abdomen. It also significantly reduces post-operative fever and facilitates early appearance of bowel sounds hence early recovery. Super-oxidized solution requires no dilution or special handling or disposal. This solution is less expensive than antibiotics. Thus, super-oxidized solution could become a useful adjuvant therapy in patients with peritonitis of any cause along with normal saline.

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