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Predictive Value of Procalcitonin for the Diagnosis of Bowel Strangulation

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Abstract. Intestinal obstruction is responsible for 3% of admissions to hospital emergency surgical departments, but it is difficult to distinguish simple obstruction from strangulation. Simple criteria for this distinction are sought. In this experimental study, procalcitonin, a known marker of bacterial inflammation, was used to detect strangulation. The predictive value of procalcitonin for small bowel strangulation was evaluated. Thirty male New Zealand rabbits (mean weight: 3.0 kg) were divided into three groups. In the first (control) group, only laparatomy was performed. In the second group, simple obstruction was created by ligating a 10-cm distal ileum segment. In the third group, distal strangulation was created by ligating a 10-cm distal ileum segment with the mesentery. Blood (1 cc) was taken from the right auricular vein of each animal for measuring the procalcitonin level. In both the control group and the simple obstruction group the procalcitonin levels were normal. In the strangulation group, elevation of procalcitonin was detected after 30 minutes, and the elevation was statistically significant at 120th minute compared with the control and simple obstruction groups. In patients with small bowel obstruction, measurement of procalcitonin levels is easy to perform and can be used in the follow-up. A more extensive clinical study is needed to evaluate the accuracy of the test as a marker.

Intestinal obstruction is responsible for 3% of admissions to hospital emergency surgical departments [1]. Surgeons are concerned by small bowel obstruction cases because strangulation might be involved, and it is difficult to distinguish simple obstruction from strangulation. Therefore the rule "never allow the sun to rise and to go down on patients who have bowel obstruction" continues to be emphasized [2]. Recent studies postulate that adhesive bands are responsible for 50% of small bowel obstructions [1, 3–5].

Accurate early recognition of intestinal strangulation in patients with mechanical small bowel obstruction is important to allow nonoperative management for selected patients [1, 2, 6, 7]. Traditionally, such recognition is based on the presence of one or more of the classical signs: vascular compromise, continuing (as opposed to colicky) abdominal pain, fever, tachycardia, evidence of peritoneal irritation, leukocytosis, hyperamylasemia, and metabolic acidosis [5, 6]. However, retrospective studies suggest that these individual indicators cannot be relied on for detecting or excluding strangulation [3, 5, 6].

In this experimental study, procalcitonin, a 116 amino acid propeptide of calcitonin with a molecular weight of 13 kDa, known as a marker of bacterial inflammation, is used for the detection of strangulation. The predictive value of procalcitonin for the diagnosis of small bowel strangulation is evaluated.

Materials and Methods

Thirty male New Zealand rabbits (mean weight: 3.0 kg) were divided into three groups. Before the experiment rabbits were kept in the animal laboratory of the Firat University School of Medicine at room temperature, and were given free water and standard laboratory feed. Rabbits were anesthetized with intramuscular (IM) ketamine hydrochloride (HCl) (35 mg/kg) and intraperitoneal xylazine (5 mg/kg). The first group was the control group, in which only laparatomy was performed. In the second group, simple obstruction was created by ligating a 10-cm distal ileum segment, 10 cm above the cecum. In the third group, distal strangulation was created by ligating a 10-cm distal ileum segment with the mesentery. Blood (1 cc) was taken from the right auricular vein of each animal 0, 15, 30, 60, and 120 minutes after the procedure. The blood samples were centrifuged and sera were studied immunoluminometrically to measure procalcitonin (B.R.A.H.M.S. Diagnostica GmbH, Berlin, Germany). The cut-off value for procalcitonin was accepted as 0.5 ng/dl. We optained approval from the local research ethics committe of Firat University.

Statistical Analysis

To compare means of procalcitonin concentrations, one-way analysis of variance (ANOVA) and post-ANOVA tests (LSD and Tukey's B) were used. Statistical significance was accepted at the $p < 0.05$ level.

Results

In the control and simple obstruction groups, all procalcitonin levels were normal. In the strangulation group, elevated procalcitonin levels became detectable at 30 minutes, and only one

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Table 1. Mean, standard error, minimum, and maximum values of procalcitonin in groups.

Minutes	Groups[a]	Mean (ng/dl)	Standard error	Minimum (ng/dl)	Maximum (ng/dl)
0^{th}	1	0.115	2.774E-02	0.05	0.33
	2	0.138	2.620E-02	0.05	0.33
	3	0.130	1.520E-02	0.08	0.23
15^{th}	1	0.140	2.789E-02	0.05	0.36
	2	8.3E-02	1.265E-02	0.05	0.16
	3	0.141	3.002E-02	0.08	0.32
30^{th}	1	9.6E-02	1.707E-02	0.05	0.18
	2	9.7E-02	1.136E-02	0.05	0.15
	3*	0.225	4.262E-02	0.08	0.50
60^{th}	1	0.124	2.377E-02	0.05	0.26
	2	8.0E-02	1.445E-02	0.05	0.17
	3**	0.302	5.426E-02	0.14	0.65
120^{th}	1	0.152	4.234E-02	0.05	0.45
	2	0.112	2.015E-02	0.05	0.24
	3***	0.514	5.194E-02	0.02	0.70

[a]Group 1: control group; group 2: distal simple obstruction group; group 3: distal strangulation obstruction group.
*Statistically significant only with simple obstruction group (group 2) ($p < 0.05$; one-way ANOVA test).
**Statistically significant only with simple obstruction group (group 2) ($p < 0.05$; one-way ANOVA test).
***Statistically significant with both groups (groups 2, 3) ($p < 0.05$; one-way ANOVA test).

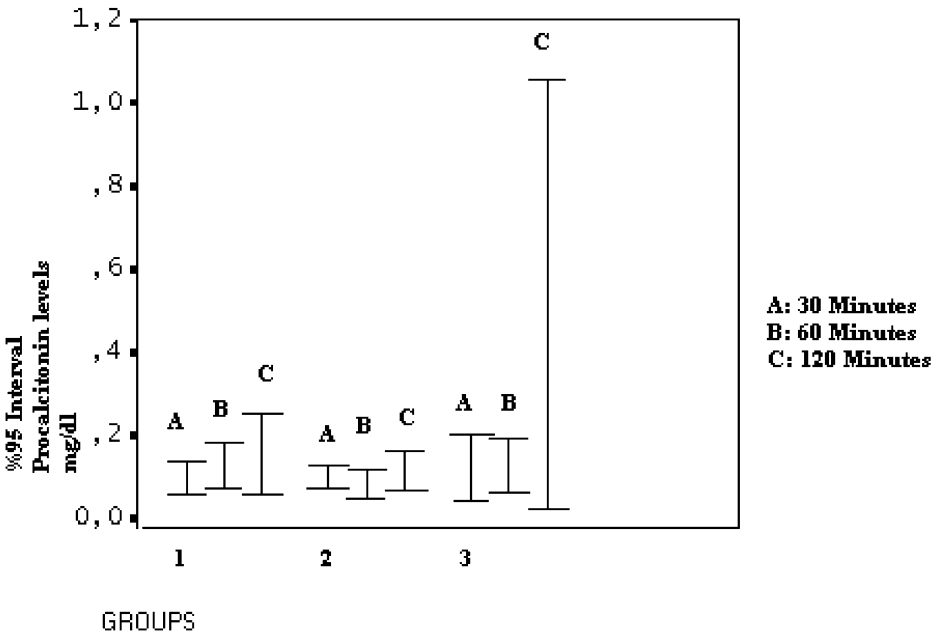

Fig. 1. The three groups are shown at the 30th, 60th, and 120th minutes at the 95% interval. A: 30 minutes; B: 60 minutes; C: 120 minutes. Group 1: Control group; group 2: distal simple obstruction group; group 3; distal strangulation obstruction group.

procalcitonin level was pathological. Compared with the control group, the elevation in procalcitonin was statistically significant ($p = 0.004$), but it was not statistically significant in comparison with the simple obstruction group ($p = 0.06$). At 60 minutes, two of the samples were pathological. Again, the elevation of procalcitonin was significant in comparison to the control ($p = 0.006$), but not the simple obstruction group ($p = 0.25$). At 120 minutes, seven pathological procalcitonin levels were observed in group 3 and the elevation was statistically significant as compared with both the control and the simple obstruction group ($p < 0.05$) (Table 1). Ninety-five percent confidence limits are shown for 30, 60, and 120 min (Fig. 1).

Discussion

Operative management for small bowel obstruction is still controversial. There is continuing debate among surgeons about whether adhesive small-bowel obstruction is best managed operatively (with laparotomy and adhesiolysis) or nonoperatively (by use of nasogastric decompression and bowel rest until normal bowel function returns). On the one hand, prior abdominal operations are now known to be the principal cause of the problem. Operative management can lead to the formation of new adhesions, which in turn can contribute to recurrence. On the other hand, the advisability of using nonoperative management in clinically stable cases has been questioned because it leaves in place both the adhesions and possibly unrecognized ischemic bowel [1].

Leukocytosis, tachycardia, localized abdominal pain, and fever, which are the classical indicators of a nonviable bowel, have been evaluated in several studies [3, 5]. It appears that even experienced clinicians are unable to diagnose strangulation obstruction preoperatively with any accuracy [6].

Intraperitoneal injection of xenon-133 in animals with strangulated bowel obstruction was used to detect the ischemia, but no

clinical use of xenon-133 in the diagnosis of ischemic bowel disease has been reported [8].

It has been suggested recently that elevated serum inorganic phosphate might be an important diagnostic hint. However, analysis indicated that the serum phosphate concentration was only elevated in patients with extensive bowel ischemia. Although it is therefore not a sensitive indicator of intestinal ischemia, an elevated serum phosphate concentration indicates poor outcome [9].

The fibrinolytic marker D-dimer has been used extensively in the diagnosis of venous thromboembolism, but the results remain controversial. Interest was stimulated by an incidental finding of raised D-dimer level on admission in a patient who had an embolus to the superior mesenteric artery. Acosta et al. concluded that a more extensive prospective study is needed to evaluate a potential survival benefit of the test as a marker of the need for urgent laparotomy [10].

The use of barium studies for the diagnosis of small bowel obstruction is becoming increasingly helpful, especially in cases where the plain films or clinical picture are nondiagnostic. But this technique is highly risky when complete obstruction or strangulation is present [5, 11, 12].

Ultrasonography is easy to perform. Bowel dilatation, fluid collections, thickening of the bowel wall, and bowel kinetics can be identified, but the efficiency of this diagnostic technique may be limited by gas in the bowel, obesity, or individual dependency [13–15]. Based on computurized tomography (CT), it is usually difficult to predict intestinal necrosis by evaluating separate findings [16–19].

Plasma procalcitonin levels are elevated in severe bacterial, fungal, and parasitic infections, as well as in sepsis and multiorgan failure. Autoimmune, allergic, and viral diseases do not increase serum procalcitonin [20, 21]. Procalcitonin can be used as an indicator in sepsis [22, 23], infected necrosis of acute pancreatitis [24], early postoperative complications [25, 26], neonatal infections [27, 28], and tropical diseases [29], and in predicting rejection of transplanted organs [30]. In this study, procalcitonin values were normal in the control and simple obstruction groups. In the strangulation group 1, the procalcitonin level was pathologically high at 30 minutes, whereas at 60 minutes two results were high, and at 120 minutes seven procalcitonin results were high. At 120 minutes the elevation was statistically significant compared to the simple obstruction group ($p < 0.05$).

We conclude that, in patients with small bowel obstruction, detection of procalcitonin levels is easy to perform and can be used in the follow-up. A more extensive clinical study is needed to evaluate the accuracy of the test as a marker.

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