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RÜÇHAN BAHADIR CELEP

ŞAHİN KAHRAMANCA

MUSTAFA ÖZSOY

CEM AZILI

SÜLEYMAN ÇETİNKÜNAR

See next page for additional authors

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Effects of intraabdominal pressure on mean platelet volume during laparoscopic cholecystectomy

Rüçhan Bahadır CELEP[1,*], Şahin KAHRAMANCA[2], Mustafa ÖZSOY[1], Cem AZILI[2], Süleyman ÇETİNKÜNAR[3], Ahmet Oğuz HASDEMİR[2], Hakan GÜZEL[2], Gülay ÖZGEHAN[2], İbrahim ÇOLHAN[2], Tevfik Hadi KÜÇÜKPINAR[2]

[1]Department of Surgery, Faculty of Medicine, Afyon Kocatepe University, Afyonkarahisar, Turkey
[2]Department of Surgery, Ankara Dışkapı Yıldırım Beyazıt Training and Research Hospital, Ankara, Turkey
[3]Department of Surgery, Adana Training and Research Hospital, Adana, Turkey

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Background/aim: Intraabdominal hypertension is a common occurrence, especially in intensive care unit patients, and it has high mortality and morbidity rates. The onset is commonly insidious and the poor prognosis is attributed to the long delay in diagnosis. Unfortunately, diagnosis is often delayed until loss of function in the affected tissues has already occurred. The aim of this study was to determine the predictive value of mean platelet volume (MPV) in assessing the risk of intraabdominal hypertension.

Materials and methods: Pneumoperitoneum during elective laparoscopic cholecystectomy was used as a model for intraabdominal hypertension. The study included 103 patients who met the inclusion criteria. MPV evaluations were made at 3 distinct times during laparoscopic cholecystectomy based on the actual intraabdominal pressure.

Results: MPV values during preinsufflation, insufflation, and desufflation were 8.483 fL (range: 6.7 to 11.1), 8.901 fL (range: 6.8 to 11.9), and 8.538 fL (range: 5.8 to 10.9), respectively. A statistically significant increase in MPV values was found during high intraabdominal pressures ($P < 0.001$). A significant decrease in MPV values was also detected with desufflation ($P < 0.001$).

Conclusion: Increasing MPV values may reflect increased intraabdominal pressures, which may have a clinical implementation in intraabdominal hypertension.

Key words: Mean platelet volume, intraabdominal hypertension, pneumoperitoneum

1. Introduction

Intraabdominal hypertension (IAH) is seen mostly in intensive care unit patients undergoing major abdominal surgery. IAH can lead to lethal cardiovascular, respiratory, and renal complications (1,2). In 2004, the World Society of the Abdominal Compartment Syndrome described IAH as a sustained or repeated pathologic elevation of intraabdominal pressure (IAP) to ≥12 mmHg (2). If not prevented or treated properly, IAH can rapidly processes to a lethal state called abdominal compartment syndrome (ACS). Recent studies have mainly been focused on developing noninvasive, inexpensive, and practical methods for the early diagnosis of IAH and ACS.

Mean platelet volume (MPV) is an indirect indicator for platelet functions. Larger platelets have more thromboxane A2-containing dense granules, which are associated with higher activity (3,4). Increased MPV is associated with a variety of conditions and diseases such as smoking, diabetes, ischemic coronary diseases, and thromboembolism. Many studies have shown that increased MPV can be used either as a diagnostic or predictive marker in the above-mentioned conditions. MPV is a standardly assessed parameter within a complete blood count, but often clinicians do not pay enough attention to MPV levels.

This study used pneumoperitoneum during laparoscopic cholecystectomy as an experimental model that mimics the IAH state. This model was intended to identify the effects of high IAP on MPV. If any significant changes occurred, then alterations in MPV could be used to predict increases in IAP. The final aim of the study was to determine whether MPV values may reflect IAH.

2. Materials and methods

This study was conducted between January 2012 and December 2012 as a prospective randomized control study with approval from the review board and ethics committee of the hospital.

* Correspondence: bahadircelep@hotmail.com

2.1. Patient selection

All patients were assessed before operation by a consultant anesthetist. Patients with symptomatic gallstone disease according to American Society of Anesthesiologists (ASA) physical status I or II were included in this study after giving informed consent. Any condition or disease known to affect MPV was determined to be an exclusion criterion. Exclusion criteria were any serious or unstable disease, diabetes mellitus, any cardiovascular disease, hypertension, hepatic or renal impairment, any pulmonary disease, and coagulation disorders. Patients converted from laparoscopy to open cholecystectomy and patients with a positive history of previous abdominal operations, cancer, clinically significant allergic reactions, and alcohol or drug abuse/dependency were also excluded. Study inclusion criteria are summarized in the Table.

2.2. Perioperative management and surgical technique

The anesthesia protocol and 4-port North American laparoscopic cholecystectomy technique were identical to those of Kum et al., with the exception that in this study the intraabdominal pressure was maintained at 12 mmHg during the operation (5).

2.3. MPV assessment

Three samples of peripheral venous blood were collected from veins in the antecubital fossa into standardized tubes containing dipotassium ethylenediaminetetraacetic acid (EDTA) under general anesthesia. The first sample (preinsufflation) was taken just after the general anesthesia. The second sample (insufflation) was taken after cutting the ductus cysticus and arteria cystica. The last sample (desufflation) was taken just after completing the operation and before reversing the effects of general anesthesia. All the blood samples were processed within 30 min after blood collection on a Coulter LH 780 Hematology Analyzer (Beckman Coulter Inc., USA). The normal range for MPV was 7.2–11.1 fL.

2.4. Statistical analysis

All statistical analyses were performed using SPSS 17 (SPSS Inc., USA). To test the normal distribution, the Shapiro–Wilk test was performed. Student's t-test was used for comparing the group means. $P < 0.05$ was considered statistically significant.

3. Results

The trial consisted of 103 eligible patients. The average age was 45 years (range: 18 to 52 years). There were 27 (26.2%) male and 76 (73.8%) female patients. The mean body mass index (BMI) of patients was 23.4 kg/m^2. Eighty-five percent of the patients were classified as being of ASA I physical status and the rest (15%) were classified as ASA II. The mean operation time was 50 min. No postoperative complications were seen and all patients were discharged on the first postoperative day. The alteration of average MPV values between the sexes is shown in Figure 1.

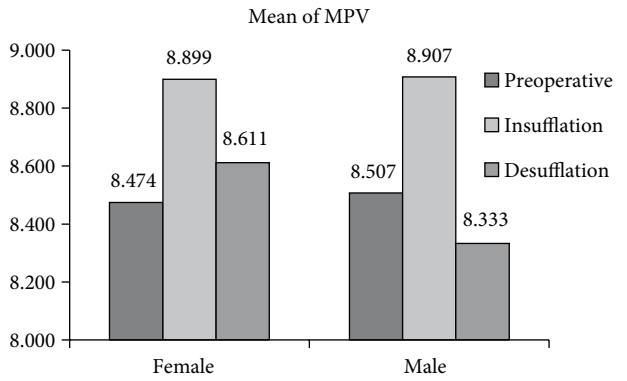

Figure 1. The alteration of average MPV values between sexes for each phase.

Table. Study inclusion criteria.

Age	18–65 years
Resting heart rate	60–100/min
Respiratory rate	<20/min
Resting blood pressure	70–130 mmHg
BMI	20–29 kg/m^2
Liver function tests (aspartate aminotransferase, alanine aminotransferase, gamma glutamyl transferase, alkaline phosphatase, bilirubin, albumin, international normalized ratio)	Normal
Renal function tests (urea, creatinine)	Normal
ASA	I–II
Operation time	45–90 min

The average for the preinsufflation MPV was 8.483 fL (range: 6.7–11.1 fL). During insufflation, MPV values were significantly higher than the preinsufflation values (mean: 8.901, range: 6.8–11.9 fL; $P < 0.001$). With desufflation the MPV values decreased and the average desufflation MPV mean was 8.538 fL (range: 5.8–10.9 fL). This decrease was also found to be statistically significant ($P < 0.001$; Figure 2).

4. Discussion

A normal IAP is 2–5 mmHg, but it may be as high as 12 mmHg in obese adults. IAH is a persistent or repeated pathological elevation of IAP at a level of ≥12 mmHg (1). The terms IAH and ACS are often mistakenly used interchangeably; however, the main difference between them is the presence of organ dysfunction in ACS (2,6). Since Kron et al. first described IAH in 1984, many reports have pointed out that up to 20% of ICU patients with abdominal trauma or surgery face a risk of developing IAH or ACS (7–10). It is now widely accepted by most authors that the first step in the occurrence of ACS is IAH. Despite progress in both diagnosis and treatment, the mortality rate for ACS is still a major issue to be solved. IAH is a dangerous situation that can rapidly progress to ACS. ACS is a life-threatening but treatable disease that requires early diagnosis and proper management. Unfortunately, physical examination has not been shown to be effective in the diagnosis of IAH and ACS (11).

Direct measurement of IAP is not practical and has many disadvantages, and so a variety of indirect methods have been described for measuring IAP by using intragastric, intracolonic, intravesical (bladder), or inferior vena cava catheters (12). Among them, intravesical pressure measurement is the generally accepted method in the diagnosis. Two previous studies clearly showed that health practitioners were inadequate in measuring and interpreting IAP in the diagnosis of IAH and ACS (13,14). More practical and easily interpretable methods are essential for detecting IAH before it progresses to ACS.

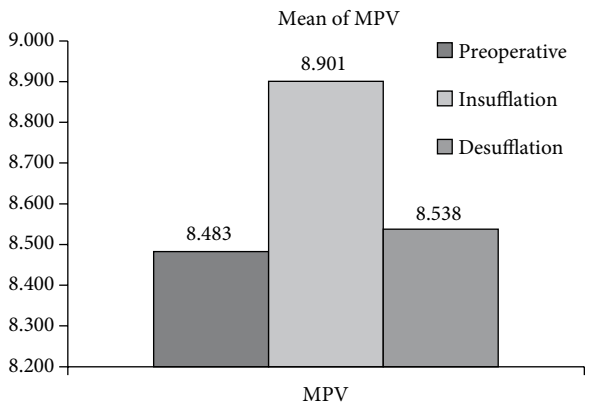

Figure 2. The average MPV values for each phase.

Early diagnosis and treatment is needed to prevent life-threatening events in both conditions. The final pathophysiology, regardless of the inciting event, is extravasation of fluid into the interstitium and bowel wall, leading to hypovolemia and increased intraabdominal pressure. This condition causes decreased renal and bowel perfusion, and also deterioration of respiratory functions (6). Previous studies intended to find the critical trigger point that worsens the perfusion of vital organs. As a result, the abdominal perfusion pressure (APP) was defined. It is simply calculated as the mean arterial pressure minus IAP. An APP of at least 60 mmHg is needed to maintain adequate perfusion to the abdominal viscera. Below this critical level, organ dysfunction can begin to occur. An increase in IAP worsens perfusion of the viscera (2,6).

Defective perfusion of the abdominal viscera leads to the secretion of free oxygen radicals and cytokines into the systemic circulation, where they cause systemic inflammatory response syndrome. This systemic inflammatory state promotes megakaryocytes (especially interleukin 3 and 6) to produce platelets (15). An increase in MPV is seen, which indicates that thrombocytes that are both metabolically and enzymatically more active than smaller ones, because large thrombocytes have more dense granules containing more thromboxane A2 (3,4). However, MPV is not paid enough attention by most clinicians; determination of MPV is a cheap, readily available, and reliable method of assessing platelet functions and is automatically calculated by hematology analyzers.

In previous studies, many conflicting results were reported. In studies about MPV, it is important to standardize the whole procedure. Machin and Briggs stressed that measurements must be done in the same standard tubes, and all samples should be evaluated in the same hematology analyzers (16). Time between sampling to analysis is another important issue, especially when the anticoagulant used in the collection tube is EDTA. It has been shown that platelets swell in EDTA and that this swelling increases with time (17). For this reason we kept the time between collection and analysis as short as possible. In our study, the time between sampling and analysis was 30 min for all samples. Evaluation of the conditions and diseases that might alter MPV values is needed and these patients must be also excluded from the study.

Although MPV quantification was established nearly 40 years ago, it has been ignored until recently, where there has been an enormous number of studies directed not only toward the counts of but also the morphology of thrombocytes. MPV has been shown to be a reliable marker of inflammation in many studies (18). An increase in MPV was shown by Van der Lelie and Van dem Borne in septicemia (19). MPV has also become a prognostic

or follow-up marker in many diseases and states, such as myocardial infarction, autonomic sympathetic overactivity, hepatic fibrosis, respiratory, cerebrovascular, and inflammatory bowel diseases (20–24). As a result of their original study including 226 patients, Bilici et al. presented MPV as a new predictive marker for acute appendicitis (25). Furthermore, Karaman et al. suggested MPV as a predictive value in differential diagnosis of nonfunctional pancreatic neuroendocrine tumors from pancreatic adenocarcinomas (26).

We hypothesized that MPV and its dynamic variation might be a reliable marker of IAH, because there are many common points between IAH and these above-mentioned studies, such as infection, bacterial translocation, ischemia, tissue necrosis, and septicemia. We found a statistically significant increase in MPV values with high IAP levels during laparoscopic insufflations and a significant decrease just after the desufflations in all patients, which supports our hypothesis. Increasing values in MPV might be related to an increase in IAP. If supported by other studies, this simple parameter could be used as a predictive marker for IAH. This approach could also be used to select patients who need invasive measurement of intraabdominal pressure.

One of the most puzzling aspects of this hypothesis is the relatively long life-span of platelets. Rapid changes in MPV are still a matter of debate, considering that the average platelet life-span is 8–10 days. Martin et al. proposed that platelet morphology is predetermined by hormonal action on the megakaryocyte (27). In contrast to that study, Thomas suggested that small platelets may be selectively retained in the organs affected by ischemia, which will induce an acute increase in MPV values (28). In our study, in a similar pattern, small platelets may have been retained in the abdominal organs, then becoming susceptible to ischemia due to the high pressure in the abdominal cavity. Another theory might be activation of the platelets by thrombopoietin. It was suggested by Boos that an in vivo swelling may occur in platelets in response to activation by thrombopoietin in particular situations, which can be seen over a period of minutes up to hours (3).

This study has 3 major limitations. First, despite being well-designed, no supporting data were provided to explain the mechanism(s) in the present study. Cytokine levels, tissue ischemia markers, and/or thrombopoietin levels might be studied to further support the hypothesis of Thomas and Boos as mentioned above. Second, the IAP was kept at 12 mmHg during the study, which corresponds to grade I IAH (grade I = IAP 12 to 15 mmHg, grade II = IAP 16 to 20 mmHg, grade III = IAP 21 to 25 mmHg, grade IV = IAP > 25 mmHg) (2,6,29). If the IAP is increased above this level, it is possible that more significant changes in MPV values would be seen. Third, the duration of increased IAP may be an important issue for IAH. In this study, the mean operation time was 50 min. If intraabdominal high pressure continues for a longer time, MPV might increase even more.

In conclusion, this is the first study that investigates the relationship between MPV and IAP increase. Increased MPV may carry a practical value for identifying patients who are at a higher risk of IAH, especially during the management of critically ill patients. Implementation of MPV measurement into clinical practice for predicting IAP may improve the management of valuable hospital resources, including time and money. Further supporting data from well-designed, randomized clinical trials are required to improve our understanding of the role of MPV in IAH.

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