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ORIGINAL ARTICLE

Portal venous pressure as a predictor of mortality in cirrhotic patients undergoing emergency surgery

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Summary *Objective:* Emergency surgery is a risk factor for mortality in cirrhotic patients. Portal hypertension is an essential feature of decompensated cirrhosis. This study aimed to assess the value of portal venous pressure (PVP) measurement in prediction of 1-month mortality in cirrhotic patients undergoing emergency laparotomy.
Methods: This prospective study included 121 adults with liver cirrhosis subjected to an emergency laparotomy. Child–Turcotte–Pugh (CTP) score and model for end-stage liver disease (MELD) score were used for preoperative patient evaluation. PVP was measured directly at the beginning of surgery. Portal hypertension (PHT) is diagnosed when PVP is greater than 12 mmHg. The primary outcome measure was the risk of mortality within one month after surgery.
Results: PVP ranged from 5 to 27 mmHg; 82 patients (67.8%) had PHT. Fifty-five patients (45.5%) died within 1 month. Mortality was significantly associated with increasing CTP Class, MELD score and PHT ($p < 0.001$ for all). PHT predicts mortality with a sensitivity of 83.6% and specificity of 92.8%. PHT was the only independent predictor of mortality (OR: 23.0, 95%CI: 8.9–59.4).
Conclusion: In patients with liver cirrhosis, emergency laparotomy carries a substantial risk of mortality within one month. Portal hypertension is an independent predictor of risk of mortality in these patients.

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1. Introduction

In patients with liver disease, especially those with compromised hepatic synthetic function, surgery can precipitate hepatic decompensation.[1] In patients with liver cirrhosis, surgery carries a significant risk of morbidity and mortality.[2] Previous investigators reported an overall mortality rates reaching 45% in patients with cirrhosis undergoing non-hepatic surgery.[3,4]

It has been shown that emergency surgery is not uncommonly performed in cirrhotic patients; about 10% of them will need surgery in the last years of their life.[5,6] Emergency surgery is a risk factor for mortality in cirrhotic patients. Meunier et al reported a mortality rate of 25% in surgery for colonic obstruction and 66% in cases of peritonitis in a group of cirrhotic patients subjected to colorectal surgery.[7]

Portal hypertension is an essential feature of decompensated cirrhosis. It is defined as a portal pressure above 10[8] or 12 mmHg.[9] With portal hypertension, cirrhotic patients are put at higher risk of postoperative complications after abdominal surgery. Surgery may cause collateral dilation with subsequent reflexive hypotension and end-organ ischemia.[10]

This study aimed to assess the value of portal venous pressure measurement in prediction of 1-month mortality in cirrhotic patients undergoing emergency laparotomy.

2. Patients and methods

This prospective study included 121 adult patients with liver cirrhosis who were subjected to an emergency laparotomy between March 2016 and March 2018 in Kasr-Al-Ainy University hospitals. The inclusion criteria were all degrees of liver cirrhosis regardless of its etiology in patients aged from 18 to 65 years presenting with acute abdomen, signs of peritonitis or intestinal obstruction. Patient with acute liver failure or hepatocellular carcinoma, preoperative portal or mesenteric vein thrombosis, or traumatic injuries were excluded from the study.

The protocol of the study was consistent with ethical guidelines of the 1975 declaration of Helsinki and its modifications. It was approved by the Research Ethics Committee (REC) of Cairo University (No.n-12-2016 in 4-2-2016). An informed permissive approval was obtained from each patient before participation along with the informed consent of the operation.

The preoperative evaluation included a detailed history, clinical examination and full investigations including CBC, bleeding profile, and liver and kidney function tests. A multi-discipline team was established with internists to deal with the liver condition and other comorbidities. Child—Turcotte—Pugh (CTP) score and model for end-stage liver disease (MELD) score were used for preoperative patient evaluation.

Preoperative CTP score was assessed according to the model including serum bilirubin, albumin, prothrombin time, amount of ascites, and hepatic encephalopathy.[11] MELD score was calculated using the formula[12]: 9.6 × log (creatinine [mg = dL]) + 3:8 × log (bilirubin [mg = dL]) + 11:2 × log (INR) + 6:4; where INR is the international normalized ratio.

Intraoperative portal venous pressure (PVP) was measured using an 18-gauge catheter inserted into one of the large jejunal, ileal, or mesenteric tributaries, or the main inferior mesenteric vein. The other end was connected through an extension-arterial line drawn via the surgical wound to a pressure transducer. If accessible, the pressure of both the main inferior mesenteric vein and one large mesenteric tributary was measured, and the mean value was calculated. Portal hypertension is diagnosed when PVP is greater than 12 mmHg.[12] One reading of the PVP was obtained at the beginning of surgery if feasible. A figure-of-eight stitch was done if persistent bleeding occurred from the puncture site after adequate compression.

According to the occurrence of postoperative mortality, the studied patients were divided into two groups. Mortality Group included patients who died during the postoperative period up to 30 days, and Surviving Group included those who survived the procedure.

The primary outcome measure was the risk of mortality within one month after surgery. The secondary outcome measure was the relation of PVP to other pre-operative variables including CTP and MELD scores, laboratory characteristics and mean intra-operative central venous pressure.

2.1. Statistical methods

Statistical analysis was done using IBM© SPSS© Statistics version 23 (IBM© Corp., Armonk, NY, USA). Numerical data were expressed as a mean and standard deviation or median and range as appropriate. Qualitative data were expressed as frequency and percentage. Chi-square test (Fisher's exact test) was used to examine the relationship between qualitative variables. For quantitative data, the comparison between two groups was made using independent sample t-test or Mann—Whitney test. Odds ratio (OR) with it 95% confidence interval (CI) were used for risk estimation. Multivariate analysis was done using logistic regression method for the significant factors affecting mortality on univariate analysis. The Receiver Operating Characteristic (ROC) curve was used for prediction of cut off values. A p-value <0.05 was considered significant.

3. Results

Tables 1—3 show the baseline characteristics, prognostic classification and laboratory characteristics of the whole studied group. Diabetes mellitus was found in 40% of cases. Peritonitis due to a perforated viscus was the most frequent indication of emergency surgery in the studied group.

Portal venous pressure ranged between 5 and 27 mmHg. Portal hypertension was diagnosed in 82 patients (67.8%). PVP was positively correlated with central venous pressure ($r = 0.712$, $p < 0.001$).

The median hospital stay was 15 days, ranging from 3 to 29 days. Within one month, 55 patients (45.5%) died. The cause of death was sepsis (n = 28, 23.1%), liver failure (n = 20, 16.5%), pulmonary embolism (n = 4, 3.3%) and myocardial infarction (n = 3, 2.5%). Table 4 show

Table 1 Baseline characteristics of the whole studied group (n = 121).

	Value
Age (years)	48.5 ± 7.6
Sex (male/female)	109/12
Body mass index (kg/m^2)	27.4 ± 3.0
Diabetes mellitus	40 (33.1%)
Hypertension	14 (11.6%)
Presentation	
Intestinal obstruction	44 (36.4%)
Peritonitis	77 (63.6%)
Operation	
Obstructed hernia	20 (16.5%)
Strangulated hernia	21 (17.4%)
Perforated duodenal ulcer	30 (24.8%)
Perforated appendix	20 (16.5%)
Cancer colon	11 (9.1%)
Others	19 (15.7%)

Data are presented as mean ± SD or no. (%).

Table 2 Prognostic classification, portal pressure and central venous pressure of the whole studied group (n = 121).

	Value
Child–Pugh class	
A	33 (27.3%)
B	42 (34.7%)
C	46 (38.0%)
MELD score	13 (4–28)
≤8	15 (12.4%)
9–16	68 (56.2%)
>16	38 (31.4%)
Portal pressure (mmHg)	
Mean ± SD	12.9 ± 4.8
Median ± range	12 (5–27)
Central venous pressure (mmHg)	10.2 ± 2.5

Data are presented as mean ± SD, median (range), or no. (%).

Table 3 Laboratory characteristics of the whole studied group (n = 121).

	Value
Hemoglobin concentration (g/dL)	9.53 ± 1.00
Total leukocytic count (×10^3/mm^3)	9.71 ± 3.08
Platelet count (×10^3/mm^3)	96 (12–231)
C-reactive protein (CRP) (mg/dL)	24 (6–96)
International normalized ratio (INR)	1.87 ± 0.66
Total bilirubin (mg/dL)	1.63 ± 0.76
Aspartate aminotransferase (U/L)	58 (16–265)
Alanine aminotransferase (U/L)	76 (14–454)
Alkaline phosphatase (U/L)	121 (49–343)
Gamma glutamyl transferase (GGT) (U/L)	119 (48–321)
Albumin (g/dL)	2.96 ± 0.69

Data are presented as mean ± SD, or median (range).

comparison between the mortality group (n = 55) and the surviving group (n = 66).

Operations for intestinal obstruction in patients with colon cancer was associated with the highest mortality compared to other procedures. The lowest mortality rate was associated with duodenal ulcer. Mortality was significantly more common with increasing CTP Class, MELD score and portal venous pressure (Table 5). Using ROC curve, PVP >12 mmHg can predict mortality with a sensitivity of 83.6% and specificity of 92.8%. The OR of portal hypertension (PVP > 12 mmHg) was 23.0 (95%CI: 8.9–59.4). In a logistic regression model, portal hypertension was the only independent predictor of mortality.

4. Discussion

This study demonstrated that 1-month mortality in cirrhotic patients undergoing non-trauma emergency laparotomy is significantly associated with increasing CTP Class and MELD score and portal hypertension. However, portal hypertension (defined as PVP > 12 mmHg) is the only independent risk factor of mortality with an OR of 23.0 (95%CI: 8.9–59.4). PVP >12 mmHg can predict mortality with a sensitivity of 83.6% and specificity of 92.8%.

It was recognized that liver dysfunction in cirrhotic patients increased the risk of coagulopathy leading to excessive perioperative bleeding, hepatic hypoperfusion, septic complications, and multi organ dysfunction.[2,4] These adverse effects can substantially increase the risk of perioperative mortality in these patients.[11,13] Many studies increased the awareness of these high-risk surgical patients. The risk of surgery in cirrhosis patients has been studied in many surgical fields including trauma,[4] cardiovascular,[13] and general surgery,[11]

Efforts have been made to define the risk predictors in an attempt to minimize the risk and improve the outcome of these surgical procedures. Among these factors are the percentages of patients with high CTP or MELD score. However, predicting survival regarding CTP versus MELD scores yielded conflicting results.[11,14–16] In the current study, we assessed portal venous pressure as an additional predictor of mortality in cirrhotic patients undergoing emergency laparotomy. In a multivariate model, CTP and MELD score were excluded from the equation in favor of portal hypertension which appeared as the only independent factor predicting 1-month mortality in the current series.

An inherent problem of CTP score is the inclusion of some subjective parameters and others that can be influenced by therapy. Also, the categorization of continuous laboratory factors may reduce the discriminative power of the model.[17] In fact, the MELD score has been mainly concerned with the 90-day mortality rates since its introduction.[12] A previous study reported that MELD score was the only independent factor predicting 30-day mortality in patients with cirrhosis undergoing cardiopulmonary bypass. However, the odds ratio was only 1.12 with a 95% confidence interval 1.03 to 1.23.[13]

We believe that inclusion of portal venous pressure can add an objective dimension to the models used for risk stratification of cirrhotic patients. For assessment of

Table 4 Comparison between mortality and surviving groups regarding baseline characteristics and type of emergency surgery.

	Mortality group (n = 55)	Surviving group (n = 66)	p Value
Age (years)	49.2 ± 7.7	47.9 ± 7.5	0.346
Sex			
Male	49 (45.0%)	60 (55.0%)	0.769
Female	6 (50.0%)	6 (50.0%)	
Body mass index (kg/m^2)	27.8 ± 2.6	27.0 ± 3.2	0.138
Diabetes mellitus			
Yes	19 (47.5%)	21 (52.5%)	0.751
No	36 (44.4%)	45 (55.6%)	
Hypertension			
Yes	6 (42.9%)	8 (57.1%)	0.836
No	49 (45.8%)	58 (54.2%)	
Presentation			
Intestinal obstruction	23 (52.3%)	21 (47.7%)	0.255
Peritonitis	32 (41.6%)	45 (58.4%)	
Operation			
Obstructed hernia	7 (35.0%)	13 (65.0%)	0.033
Strangulated hernia	9 (42.9%)	12 (57.1%)	
Perforated duodenal ulcer	9 (30.0%)	21 (70.0%)	
Perforated appendix	9 (45.0%)	11 (55.0%)	
Colon cancer	9 (81.8%)	2 (18.2%)	
Others	12 (63.2%)	7 (36.8%)	

Data are presented as mean ± SD or no. (%).

Table 5 Prognostic classification, portal venous pressure and central venous pressure in mortality and surviving groups.

	Mortality group (n = 55)	Surviving group (n = 66)	p Value
Child—Pugh class			
A	5 (15.2%)	28 (84.8%)	
B	16 (38.1%)	26 (61.9%)	<0.001
C	34 (73.9%)	12 (26.1%)	
MELD score	16.3 ± 4.5	12.2 ± 4.8	<0.001
≤8	1 (6.7%)	14 (93.3%)	
9—16	29 (42.6%)	39 (57.4%)	<0.001
>16	25 (65.8%)	13 (34.2%)	
Portal venous pressure (mmHg)	16.4 ± 4.2	10.0 ± 3.0	<0.001
≤12	9 (14.3%)	37 (94.9%)	<0.001
>12	46 (79.3%)	29 (35.4%)	
Central venous pressure (mmHg)	11.7 ± 1.8	9.0 ± 2.4	<0.001

Data are presented as mean ± SD or no. (%).

surgical risk, PVP cannot be ignored and should be at least a part of perioperative risk stratification of cirrhotic patients. Definite portal hypertension can compromise the kidneys, the heart, and the endocrine system via the hyperdynamic circulatory changes involving splanchnic vessels, lungs and arterial cardiovascular compartment.[18,19]

Therefore, PVP measurement reflects the general condition of the patient and not only the liver status. In the current study, it was more reliable in predicting mortality with a sensitivity of 83.6% and specificity of 92.8%.

In support of our idea, elevation of portal pressure as measured by hepatic venous pressure gradient (HVPG) was found to be an independent prognostic indicator for most relevant events in cirrhosis. It correlates with the risk of varices formation, clinical decompensation, and development of hepatocellular carcinoma in patients with compensated cirrhosis.[20,21]

We measured PVP directly at the beginning of surgical procedure with a catheter inserted into one of the large jejunal, ileal, or mesenteric tributaries, or the main inferior mesenteric vein. However, in practice, portal hypertension can be determined by HVPG which is the gradient between the pressure in the portal vein and the inferior vena cava. Normally, it ranges from 1 to 5 mmHg.[22] HVPG values >10 mmHg correspond to clinically significant portal hypertension.[23] Another diagnostic tool in the evaluation of

portal hypertension is the use of upper GI endoscopy for the detection of varices.[24]

Despite being safe, HVPG measurement and upper GI endoscopy are minimally invasive techniques that cause patient discomfort and increase the cost of medical care. This situation stimulated further research to provide reliable and non-invasive alternatives for assessment of portal hypertension. Researchers continue to validate the use of new techniques such as transient elastography[25] and CT, MR, and US-based hemodynamic analysis with promising results in this field.[26]

Therefore, noninvasive preoperative assessment of portal venous pressure can be a valuable element for building a more reliable risk stratification platform of the surgical risk of cirrhotic patients. Certainly, an emergency procedure cannot be delayed or barred; we can reassess an elective procedure in high-risk cases. Measures to control portal hypertension may be the hope to reduce the high mortality risk when surgery is inevitable in emergency situations.

The main limitation of this study is mortality assessment during the first 30-days postoperatively. In fact, 30-day mortality rates are commonly used in reporting surgical outcomes. However, some investigators reported a significant increase in mortality after hepatic and general surgery between 30 and 90 days, which can be attributed to a decrease in liver function.[11,27]

In conclusion, in patients with liver cirrhosis, emergency laparotomy carries a substantial risk of mortality within one month. CTP class and MELD score are among the main predictors of mortality in these cases. However, portal hypertension is an independent predictor of risk of mortality of cirrhotic patients undergoing emergency laparotomy.

Conflict of interest

None.

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