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## **NON-TECHNICAL COMPLICATIONS PREDICT 30-DAY PERIOPERATIVE MORTALITY IN ABDOMINAL SURGERY. A PROPENSITY SCORE MATCHED ANALYSIS \***

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Abbreviations: ASA (American Society of Anesthesiologists), HPB (Hepato Pancreatico Biliary), ARDS (Acute Respiratory Distress Syndrome)

### **Abstract**

**Introduction:** Surgical complications are a major cause of mortality and morbidity. Non-technical complications seem to be more dangerous than technique-related complications, however they are commonly neglected by surgeons. Aim: To study the relationship between non-technical complications and mortality after gastrointestinal and hepatobiliary surgery.

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**Material and Methods:** All gastrointestinal and hepatobiliary procedures performed over 3 years in one center were analysed. Non-technical postoperative complications were defined as perioperative complications related to patients' physiological health or comorbidities, rather than surgical procedures or techniques. To avoid selection bias we conducted a 1:1 propensity score match analysis with non-technical complications as a dependent factor. The propensity scores were calculated using logistic regression. Pre-operative confounding factors such as age, sex, American Society of Anesthesiologists (ASA) score and type of surgery were entered into our model as covariates. We used the nearest-neighbor protocol with a caliber of 0.2. The cases were not reusable after matching. The statistics were analyzed using SPSS version 23.

**Results:** A total of 348 patients underwent gastrointestinal and HPB (Hepato Pancreatico Biliary) surgery in Hepatobiliary and Liver Transplant Department of Shalby Hospitals, India between April 2017 and March 2020. Twenty-four patients developed non-technical complications. ASA scores independently predicted non-technical complications ( $p=0.001$ , odds ratio 3.955, 95% C.I.: 1.774–8.813). After matching with 23 controls, non-technical complications were still significantly correlated with mortality ( $p<0.0001$ ). Intraoperative factors did not predict non-technical complications. Surgery-related complications were not associated with mortality after matching.

**Conclusion:** Non-technical complications are associated with a significant risk of mortality.

**Key words:** mortality, hepatobiliary surgery, surgical critical care, complications

## Introduction

Surgical complications are a major cause of mortality and morbidity [1], and their incidence rate can be as high as 30% in some groups of patients [2,3]. They generally consist of two types of complication, i.e. technique or surgical-procedure related complications, e.g. bleeding or anastomotic leaks, and non-technical complications, which occur due to surgical stress, e.g. Acute Respiratory Distress Syndrome (ARDS), acute kidney injury, postoperative acute left ventricular failure or acute postoperative delirium [4]. We assumed that non-technical complications are more dangerous than technique-related complications, and yet they are commonly neglected by surgeons.

Our primary aim was to study the relationship between non-technical complications and mortality. The secondary aim was to determine the factors responsible for non-technical complications.

## Material and Methods

All gastrointestinal and hepatobiliary procedures performed in the last 3 years were evaluated retrospectively.

Non-technical complications were defined as perioperative complications related to patients' physiological health or comorbidities (e.g. acute kidney injury, ARDS, acute respiratory failure, cardiac complications etc.), rather than to surgical procedures or techniques.

Technical complications were defined as perioperative complications related to surgical procedures or techniques (e.g. bleeding, leaks, sepsis etc.).

### *Study Design*

A retrospective analysis of prospectively collected data regarding all patients who underwent gastrointestinal and hepatobiliary surgery at our center between April 2017 and March 2020 was performed. All complications were classified as technical or non-technical on the basis of the definitions given above.

### *Definition of non-technical complications*

Acute kidney injury was defined according to the Acute Kidney Injury Network definition [5]. ARDS was defined according to the Berlin definition [6]. Acute myocardial infarction and postoperative left ventricular dysfunction were diagnosed as per cardiologists' opinion on the basis of cardiac markers, electrocardiogram and echocardiography. Pulmonary embolism was confirmed using a contrast enhanced CT scan.

### *Statistical analysis:*

To avoid selection bias in our attempt to evaluate the effect of non-technical complications on mortality we performed a 1:1 propensity score matching analysis with non-technical complications as a dependent factor. Propensity scores were calculated using logistic regression analysis. Preoperative confounding factors such as age, sex, American Society of Anesthesiologists (ASA) score and type of surgery were entered into our model as covariates. We used the nearest neighbor protocol with a caliber of 0.2. The cases were not reusable after matching. The statistics were analyzed using SPSS version 23 [5].

The categorical variables were analyzed using the chi square test or the Fisher exact test as per requirements. The continuous variables were analyzed using the Mann Whitney U test for nonparametric data and Student t test for parametric data. Medians were used for nonparametric data. A two-sided p value of less than 0.05 was considered as significant. We also analyzed 90-day postoperative mortality between patients who developed non-technical complications and the control group with a Kaplan-Meier analysis using the log rank test. The statistics were analyzed using SPSS version 23.

**Results**

A total 348 patients underwent various abdominal surgeries (gastrointestinal and hepatobiliary) in our department between April 2017 and March 2020. Twenty-four patients developed non-technical complications. Individual complications are listed in table 1.

Table 1. Post operative non-technical complications

Complications	Total number of patients
Acute Kidney Injury (AKI)	11
ARDS	7
Pulmonary embolism	3
Myocardial infarction	2
Postoperative left ventricular dysfunction	1

*Comparison of the groups before matching*

Comparisons of both groups, non-technical complications and controls before propensity score matching are shown in table 2.

Before propensity score matching non-technical complications were significantly higher in Upper Gastrointestinal surgery, emergency surgery, open surgery, in patients who developed intraoperative hypotension, patients operated for malignancies, patients with higher ASA grades, patients in whom more blood products were used and patients whose operations lasted longer (see Table 2 for details).

In the multivariate logistic regression analysis of preoperative factors only higher ASA scores predicted non-technical complications independently (p=0.001, odds ratio 3.955, 95% C.I.: 1.774–8.813).

Mortality was significantly higher and hospital stays were considerably longer in patients who developed non-technical complications. Surgery-related complications did not predict mortality (p=0.06).

*Post Matching analysis*

In the case of those factors affecting mortality, to avoid selection bias we carried out 1:1 propensity score matching as described in the statistical analysis. We used all the preoperative factors i.e. age, sex, ASA score and the type of surgery.

Twenty-four patients were included in the non-technical complication group and they were matched with twenty-three controls.

After matching the non-technical complications were also significantly correlated with mortality (p<0.0001). No intraoperative factors such as

intraoperative hypotension, blood product requirement and operative time predicted non-surgical technique-related complications (Table 3). Intraoperative factors were not matched.

Surgery-related complications were not associated with mortality after matching.

Post matching Kaplan Meier analysis with log rank test revealed that patients who developed non-technical complications had significantly higher 90-day mortality compared to the control. ( $p < 0.0001$ ) (Figure 1).

Table 2. Univariate and multivariate analysis of both the study and control group before propensity score matching

Factor	Non-technical cation (n=24)	Control group (n=324)	P value (univariate analysis)	Multivariate analysis for factors predicting study group
Age (median/range)	55 (34–80)	54 (7–83)	0.194	
Sex (female/male)	10/14	141/183	0.853	
ASA (n)	ASA 1=0 ASA 2=5 ASA 3=8 ASA 4=11	ASA 1=1 ASA 2=224 ASA 3=80 ASA 4=19	<0.0001	0.001. ODDS RATIO 3.955 (95% C.I.) 1.774–8.813
Intraoperative hypotension (n)	6	17	0.003	0.173
Open Surgery (n)	22	172	<0.0001	0.161
90-day Mortality	16	9	<0.0001	
Colorectal surgery (n)	5	47	0.379	
Small bowel surgery (n)	4	39	0.518	
Upper GI surgery (stomach/esophagus) (n)	4	12	0.018	0.194
Emergency surgery (n)	10	54	0.05	0.977
Malignant disease (n)	9	61	0.036	0.781
HPB surgery (n)	11	190	0.284	
Hernia (n)	0	32	0.147	
Blood product (median/range)	2 (0–15)	0 (0–40)	<0.0001	0.392
Operative time (minutes) (median/range)	120 (45–600)	90 (15–800)	0.002	0.506
Hospital stay (median/range)	4 (1–25)	2 (1–15)	0.035	

Table 3. Comparison after study and the control group after propensity score matching

Factor	Nonsurgical technique related complication (n=24)	Control group (n=23)	P value
Age (median/range)	55 (34–80)	54 (32–68)	0.535
Sex (female/male)	10/14	9/14	0.859
ASA (n)	ASA 1=0 ASA 2=5 ASA 3=8 ASA 4=11	ASA 1=0 ASA 2=6 ASA 3=13 ASA 4=4	0.104
Intraoperative hypotension (n)	6	4	0.724
Open Surgery (n)	22	18	0.245
90 days Mortality	16	0	<0.0001
Colorectal surgery (n)	5	4	1.0
Small bowel surgery (n)	4	3	1.0
Upper GI surgery (stomach/esophagus) (n)	4	2	0.666
Emergency surgery (n)	10	7	0.547
Malignant disease (n)	9	61	0.036
HPB surgery (n)	11	12	0.773
Hernia (n)	0	1	1
Blood product (median/range)	2 (0–15)	2 (0–40)	707
Operative time (minutes) (median/range)	120 (45–600)	120 (30–800)	0.707
Hospital stay (median/range)	4 (1–25)	4 (1–13)	0.972

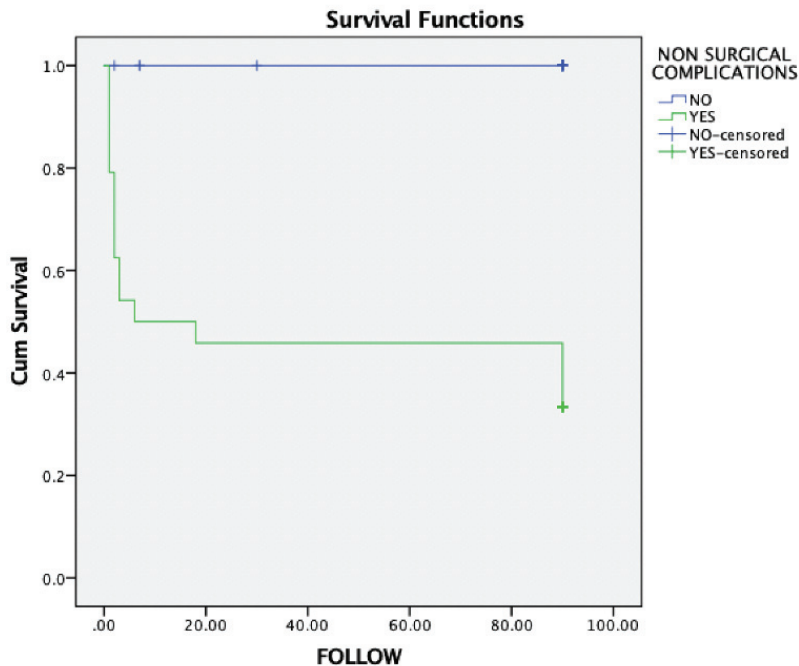


Figure 1. Kaplan Meier analysis of 90-day survival between the study and the control group after matching with log rank analysis,  $p < 0.0001$ .

## Discussion

Perioperative mortality is one of the most important problems the surgical community has to face. Perioperative mortality ranges from 0.1% to as high as 27–30%, depending on the type of surgery [7,8]. Gastrointestinal and hepatobiliary surgery are technically demanding procedures and have among the highest perioperative mortality rates [9–11].

Surgeons are always worried about the technical aspects of surgery, although very few studies have been carried out that look at the impact of non-technical complications on perioperative mortality. There are various perioperative complications, which are not actually related to surgical techniques and depend on many factors, such as patients' preoperative conditions as well as a perioperative course of anesthesia. These complications can include, but are not limited to, acute kidney injury, ARDS, post operative delirium, myocardial infarction, and postoperative acute left ventricular dysfunction. These complications can also contribute significantly to overall mortality [12,13].

The aim of this study was to analyze the effect of non-technical complications and technical complications on mortality. For gastrointestinal and

hepatobiliary surgery we defined anastomotic leaks, sepsis due to leaks, intraoperative bleeding, and iatrogenic injuries to the surrounding structure as technical complications, and other complications, such as acute kidney injury, ARDS, as non-technical complications.

Since mortality can be affected by preoperative status of the patient as well as type of surgery, to avoid these confounding factors and selection bias we performed a 1:1 propensity score match analysis.

In an unmatched univariate analysis upper gastrointestinal surgery (gastric and esophageal), emergency surgery, open surgery, intraoperative hypotension, cancer surgery, higher ASA score, the use of blood products and longer operative time were risk factors for developing non-technical complications. On a multivariate analysis only a higher ASA grade predicted non-technical complications.

After the 1:1 propensity score matching there was no significant difference in any preoperative factors, which were matched between the two groups; this suggests adequate matching. After matching, non-technical complications were significantly correlated with mortality. Matching of all the preoperative surgery-related or patients' physiology-related parameters confirmed that non-technical complications were associated with postoperative mortality. However, they were not associated with an increased hospital stay post matching, unlike the pre-matching analysis.

After matching, intraoperative factors, such as increased operative time, greater blood product requirement or intraoperative hypotension did not predict non-technical complications. This may suggest that surgeons had very little control over them and non technical complications depend on patients' preoperative physiological states, as suggested by the ASA grades, which was seen in our pre-match multivariate analysis.

Surgery-related complications did not predict mortality in pre-match analysis as well as in post-match analysis.

After propensity score matching the Kaplan Meier analysis also showed significantly lower 90-day survival in patients who developed non-technical complications (Figure 1).

We do not wish to say that technical complications are not harmful, but our purpose is to point out the importance of non-technical complications and their impact on surgical mortality. This study, similarly to many other studies, shows the importance of critical care management in reducing postoperative mortality [14–17].

As a retrospective analysis this study has some obvious limitations. We also require a larger sample size study to obtain more solid results. However, considering that it would be too difficult to conduct a randomized control trial on the topic, this study confirms that via good critical care management we can reduce non-technical complications and thus significantly reduce postoperative mortality.



## Conclusion

Non-technical complications are associated with a significant increase in the risk of mortality. Surgeons should concentrate on preventing and managing these complications in the most effective way.

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## **Powikłania nietechniczne prognozują 30-dniową śmiertelność okołoperacyjną w chirurgii jamy brzusznej.**

### **Analiza dopasowania tendencji**

#### **Streszczenie**

Wprowadzenie: Powikłania chirurgiczne są główną przyczyną śmiertelności i zachorowalności. Powikłania pozatechniczne wydają się być bardziej niebezpieczne niż powikłania techniczne, jednak chirurdzy często je zaniedbują. Celem pracy było zbadanie związku między powikłaniami niezwiązanymi z techniką chirurgiczną a śmiertelnością po rozległych zabiegach operacyjnych w obrębie przewodu pokarmowego, wątroby i dróg żółciowych.

Materiał i metody: Przeprowadzono analizę danych wszystkich chorych leczonych w Hepatobiliary and Liver Transplant Department of Shalby Hospitals w Indiach w okresie 3 lat z powodu schorzeń przewodu pokarmowego, wątroby i dróg żółciowych. Powikłania nietechniczne zostały zdefiniowane jako wszystkie powikłania związane ze stanem ogólnym i chorobami współistniejącymi, niemające związku z samą techniką chirurgiczną. Aby zmniejszyć ryzyko błędu wynikającego z doboru chorych, przeprowadzono dodatkowo analizę porównawczą z odpowiednio dobraną pod kątem wszystkich innych cech grupą chorych, u których takie powikłania nie wystąpiły. W analizie wykorzystano regresję logistyczną. Przedoperacyjne czynniki, takie jak: wiek, płeć, wynik w skali Amerykańskiego Towarzystwa Anestezjologów (ASA) i rodzaj operacji, zostały wprowadzone do naszego modelu jako zmienne zaburzające. Użyto protokołu najbliższego

sąsiada o kalibrze 0,2. Przypadki nie były wykorzystywane ponownie po dopasowaniu. Statystyki przeanalizowano za pomocą programu SPSS w wersji 23.

Wyniki: Ogółem operowanych było 348 chorych w okresie od kwietnia 2017 r. do marca 2020 r. U 24 chorych rozwinęły się powikłania niechirurgiczne. Wystąpienie tych powikłań było związane z wyższym wynikiem oceny przedoperacyjnej w skali ASA ( $p=0,001$ , OR 3,955, 95% CI: 1,774–8,813). W analizie grup porównawczych stwierdzono wyższe ryzyko zgonu ( $p<0,0001$ ) w grupie chorych z powikłaniami niechirurgicznymi. Powikłania techniczne związane z zabiegiem operacyjnym nie wpłynęły na zwiększenie ryzyka zgonu.

Wniosek: Powikłania niechirurgiczne u chorych operowanych w obrębie przewodu pokarmowego, wątroby i dróg żółciowych wiążą się ze zwiększeniem ryzyka zgonu.

Słowa kluczowe: śmiertelność, chirurgia wątrobowo-żółciowa, chirurgiczna opieka krytyczna, komplikacje

