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Assessment of Postoperative Complications after Major Abdominal Surgery Using the Clavien-Dindo Classification: A Prospective Observational Study from a Tertiary Care Hospital in Western India

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Abstract:

- ***Background:***

Postoperative complications are the main source of morbidity after major abdominal surgery. Few prospective data from Indian public-sector hospitals grade them in a standard way. We graded complications after major abdominal surgery with the Clavien-Dindo classification and identified their predictors.

- ***Materials and Methods:***

This was a prospective observational cohort study at a government tertiary care teaching hospital in Gujarat, India. We consecutively enrolled 150 patients older than 16 years who underwent elective or emergency major abdominal surgery and followed them to discharge or 30 days. The highest Clavien-Dindo grade per patient was recorded.

Associations were tested with the chi-square test, and independent predictors were identified by multivariable logistic regression. The study is reported according to the STROCSS 2024 guideline.

- ***Results:***

The mean age was 48.6 ± 15.2 years, and 92 patients (61.3%) were male. Sixty operations (40.0%) were emergency laparotomies. Sixty patients (40.0%) developed complications, most often surgical site infection (26.7%), ileus (16.7%) and pulmonary complications (13.3%). Grade II was the most frequent grade (36.7%), followed by Grade I (23.3%). Grade III complications occurred in 25.0% and Grade IV in 10.0% of complicated cases. Complication rates were 66.7% after emergency surgery and 22.2% after elective surgery ($p < 0.001$), 48.9% after open surgery and 20.0% after laparoscopic surgery, and rose from 16.7% in ASA I to 100% in ASA IV ($p < 0.001$). Hypoalbuminaemia and deranged PT-INR were associated with complications ($p < 0.05$). On multivariable analysis, ASA III/IV (aOR 5.0), operative duration > 4 h (aOR 4.5), emergency surgery (aOR 4.2), comorbidity (aOR 3.1) and age > 60 years (aOR 2.6) were independent predictors. Mean hospital stay rose from 6.8 days for Grade I to 25.5 days for Grade IVb. ICU admission was needed in 21.3% of patients, and in-hospital mortality was 4.7% (7/150).

- ***Conclusion:***

Two in five patients developed a complication after major abdominal surgery, and most complications were low-grade. Emergency presentation, comorbidity and high ASA grade identified high-risk patients. The Clavien-Dindo classification was simple to apply, and its grades tracked resource use, which supports its routine use for audit in Indian tertiary hospitals.

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Keywords: *Clavien-Dindo Classification; Postoperative Complications; Abdominal Surgery; Emergency Laparotomy; ASA Physical Status; Surgical Audit.*

➢ *Highlights*

- Forty percent of 150 patients had a complication after major abdominal surgery, and 60% of those were Clavien-Dindo Grade I–II.
- Emergency laparotomy carried a three-fold higher complication rate than elective surgery (66.7% vs 22.2%).
- ASA III/IV, operative duration > 4 h, emergency surgery, comorbidity and age > 60 years independently predicted complications.
- Hospital stay rose steadily with Clavien-Dindo grade, which supports the classification as an audit tool.
- The classification was easy to apply in a busy Indian public-sector surgical unit.

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I. INTRODUCTION

Major abdominal operations make up a large share of the more than 300 million surgical procedures performed worldwide each year [1]. Postoperative complications remain their main source of morbidity, prolonged hospital stay, cost and death, despite advances in anaesthesia and perioperative care [2–4]. Complications also reduce long-term survival independently of preoperative risk [3]. Failure to rescue patients after a complication, rather than the complication rate alone, explains much of the variation in mortality between hospitals [4].

The surgical literature long reported complications inconsistently. A review of 119 studies found that most lacked definitions of complications or any severity grading [5]. This makes comparison between institutions, procedures and time periods unreliable. Clavien and colleagues proposed a therapy-based grading system in 1992 [6], and Dindo et al. revised it in 2004 [7]. The revised Clavien-Dindo classification grades each complication by the treatment needed to correct it: Grade I (deviation from the normal course without specific treatment), Grade II (drug treatment, transfusion or parenteral nutrition), Grade III (surgical, endoscopic or radiological intervention), Grade IV (life-threatening complication needing intensive care) and Grade V (death). The system was validated in 6,336 patients and has since been adopted across surgical specialties [7,8]. The Comprehensive Complication Index was later built on it [9].

Most validation work comes from high-income, largely elective settings. In low- and middle-income countries, a larger share of abdominal surgery is emergency surgery, and patients often present late with sepsis, malnutrition and untreated comorbidity [10]. Emergency procedures produce more and more severe complications [11]. Indian and South Asian reports on Clavien-Dindo grading after major abdominal surgery are few and mostly small (50–78 patients) [12,13], and they seldom adjust for confounding.

We therefore conducted a prospective study in a government tertiary care hospital in western India. Our aims were to (1) measure the incidence and spectrum of complications after major abdominal surgery; (2) grade them with the Clavien-Dindo classification; (3) relate grades to patient, procedure and outcome variables; and (4) identify independent predictors of postoperative complications.

II. MATERIALS AND METHODS

➢ *Study Design and Setting*

This was a single-centre, prospective observational cohort study in the Department of General Surgery, Pandit Deendayal Upadhyay Government Medical College and Civil Hospital, Rajkot, Gujarat, India. This public teaching hospital serves a largely rural and semi-urban population. Enrolment ran for 18 months, from November 2024 to April 2026. The work is reported in line with the STROCSS 2024 criteria [14].

➢ *Ethics*

The Institutional Ethics Committee approved the study (reference PDUMCR/IEC/325/2024, dated 30 October 2024). Every participant, or a legally authorised relative for incapacitated emergency patients, gave written informed consent in English or Gujarati.

➢ *Participants*

Consecutive patients older than 16 years who underwent elective or emergency major abdominal surgery were eligible. Major abdominal surgery was defined as an operation that entered the peritoneal or retroperitoneal cavity under general or regional anaesthesia and required inpatient admission. We excluded patients aged 16 years or younger, pregnant women, patients with a previous major abdominal operation, minor or day-care procedures, patients who declined consent, and patients who left against medical advice before assessment was complete.

➢ *Sample Size*

The sample size was calculated with the formula n = ZZpq/dZ. We assumed a complication prevalence of 30%

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from published cohorts [15], 95% confidence (Z = 1.96) and an absolute precision of 7.5%. The minimum required was 144 patients. We enrolled 150 to allow for incomplete records.

➢ *Variables and Data Collection*

The operating surgical team recorded data prospectively on a structured case record form. Preoperative variables were age, sex, comorbidities, presenting symptoms, ASA physical status [16] and laboratory values. The laboratory values were haemoglobin, total leucocyte count, serum creatinine, bilirubin, albumin (abnormal if < 2.5 g/dL), PT-INR (abnormal if > 1.6), sodium and potassium. Operative variables were urgency (elective or emergency), procedure group, surgical approach (laparoscopic, open, or laparoscopic converted to open) and operative duration. Procedures were grouped as gastrointestinal, hepatobiliary, pancreatic, splenic, radical nephrectomy, emergency laparotomy, and other.

➢ *Outcomes*

The primary outcome was any postoperative complication within 30 days or before discharge, graded by the Clavien-Dindo classification [7]. Patients were reviewed daily. When a patient had more than one complication, the highest grade was recorded. Grade III complications were sub-classified as IIIa (intervention without general anaesthesia) or IIIb (under general anaesthesia), and Grade IV as IVa (single-organ dysfunction) or IVb (multi-organ dysfunction). Secondary outcomes were complication type, length of hospital stay, re-intervention, ICU admission, postoperative ventilatory support and in-hospital mortality.

Complications developing more than 30 days after surgery were not counted.

➢ *Statistical Analysis*

Data were entered in Microsoft Excel and analysed with SPSS version 31.0 (IBM Corp., Armonk, NY, USA). Continuous variables are reported as mean ± standard deviation.

Categorical variables are reported as number (%) and compared with Pearson's chi-square test, or Fisher's exact test when expected counts were below 5. Variables associated with complications on univariable analysis (age > 60 years, comorbidity, emergency surgery, operative duration > 4 hours and ASA III/IV) were entered into a multivariable logistic regression model, and results are given as adjusted odds ratios (aOR). A two-sided $p < 0.05$ was considered significant.

III. RESULTS

➢ *Patient and Operative Characteristics*

We enrolled 150 patients, and all completed follow-up. The mean age was 48.6 ± 15.2 years, and the largest age group was 51–60 years (25.3%). Males made up 61.3% of patients. Ninety patients (60.0%) had at least one comorbidity, most often hypertension (24.0%) and diabetes mellitus (20.0%). Abdominal pain was the most common presenting symptom (85.3%), followed by vomiting (54.7%) and fever (49.3%). Ninety operations (60.0%) were elective and 60 (40.0%) were emergency laparotomies. Most patients were ASA II (41.3%). Open surgery was performed in 60.0% of patients, and the mean operative time was 3.1 ± 1.2 hours (Table 1).

➢ *Incidence, Type and Grade of Complications*

Sixty patients (40.0%) developed at least one postoperative complication. Surgical site infection was the most common (16/60, 26.7%), followed by postoperative ileus (16.7%) and pulmonary complications (13.3%). By Clavien-Dindo grade, 36 complicated patients (60.0%) had Grade I or II complications, and Grade II was the most frequent (36.7%). Fifteen (25.0%) needed surgical, endoscopic or radiological intervention (Grade IIIa/IIIb), 6 (10.0%) had life-threatening organ dysfunction (Grade IVa/IVb), and 3 (5.0%) were Grade V (Table 2).

➢ *Factors Associated with Complications*

Complication rates rose with age, from 20.8% at 17–30 years to 70.8% above 60 years ($p = 0.003$). They were higher with comorbidity (55.6% vs 16.7%, $p < 0.001$) and after emergency surgery (66.7% vs 22.2%, $p < 0.001$). They rose steeply with ASA grade (16.7%, 29.0%, 60.0% and 100% for ASA I–IV, $p < 0.001$). Sex was not associated with complications ($p = 0.78$). Among procedure groups, emergency laparotomy had the highest rate (66.7%), and splenic surgery (10.0%) and radical nephrectomy (12.5%) the lowest. Laparoscopic surgery had a lower rate (20.0%) than open (48.9%) or converted (46.7%) procedures ($p = 0.005$).

Complications increased with operative time: 14.3% for < 2 h, 27.0% for 2–4 h and 100% for > 4 h ($p < 0.001$). Every abnormal preoperative laboratory value was associated with complications. The strongest associations were for serum albumin < 2.5 g/dL (70.0% vs 29.1%) and PT-INR > 1.6 (69.0% vs 33.1%) (Table 3).

➢ *Independent Predictors*

On multivariable logistic regression, five factors independently predicted postoperative complications. ASA III/IV carried the highest odds, followed by operative duration > 4 h and emergency surgery (Table 4).

➢ *Resource Use and Mortality*

Mean hospital stay rose with each Clavien-Dindo grade, from 6.8 days for Grade I to 25.5 days for Grade IVb (Table 2). Thirty-two patients (21.3%) were admitted to the ICU after surgery: 20 of 60 emergency patients (33.3%) and 12 of 90 elective patients (13.3%).

Twenty-six patients (17.3%) needed postoperative ventilatory support: 16 emergency (26.7%) and 10 elective (11.1%). Fifteen patients (10.0%) underwent re-intervention, most of them emergency cases (11/15). Of 150 patients, 143 (95.3%) were discharged and 7 died, an in-hospital mortality of 4.7%. All deaths occurred after emergency surgery (7/60, 11.7%).

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IV. DISCUSSION

In this prospective cohort of 150 patients, 40% developed a complication after major abdominal surgery. Most complications were low-grade (60% Grade I–II). Emergency presentation, high ASA grade, prolonged operations, comorbidity and older age identified the patients at risk. Hospital stay rose steadily with each Clavien-Dindo grade, which shows that the classification captures the clinical and resource burden of complications.

- *Incidence and Spectrum of Complications*

Our complication rate of 40.0% lies between the 57.7% reported by Jha et al. in 78 Nepalese patients [12] and the 16–20% typical of elective high-income cohorts [15]. The difference reflects case-mix: 40% of our operations were emergency laparotomies. In the International Surgical Outcomes Study, which included only elective surgery, 16.8% of patients developed complications [15]. Surgical site infection was our leading complication (26.7% of complicated cases), as in the study by Jha et al. (57.8%) [12]. This is consistent with the high burden of SSI after contaminated emergency surgery in low- and middle-income countries [10,17] and points to SSI prevention bundles as an immediate target for quality improvement [17].

- *Clavien-Dindo Grade Distribution*

Grade II was the most common grade, as reported by Jha et al. (42.2%) [12] and Rapaka and Reddy (32%) [13]. Most complications in surgical series need only drug treatment, which matches the original validation cohort [7]. One in three complicated patients nonetheless reached Grade III or higher. In our cohort, mean hospital stay roughly quadrupled from Grade I (6.8 days) to Grade IVb (25.5 days). This gradient supports the construct validity of the classification: each step up the scale corresponds to more intervention and more use of hospital resources [8,9]. The classification relies on the treatment given rather than subjective judgement of severity. In our experience this made it quick to apply during daily ward rounds by surgical residents, with no special training. Mentula and Leppäniemi reached the same conclusion for emergency surgery [11].

- *Predictors of complications*

ASA grade was the strongest independent predictor (aOR 5.0). Every ASA IV patient developed a complication. ASA status is a simple bedside measure of physiological reserve [16]. Kokotovic et al. found ASA ≥ 3 to be an independent risk factor for Clavien-Dindo ≥ III complications after major emergency abdominal surgery [18]. Emergency surgery independently increased risk four-fold. This agrees with Mentula and Leppäniemi, whose emergency laparotomy patients had a complication rate of 49.3% [11], and with global data showing much higher mortality after emergency abdominal surgery in low-income settings [10]. In Ethiopia, Dessalegn et al. reported 19.7% perioperative mortality after emergency laparotomy, with sepsis, delayed presentation and ICU admission as predictors [19]. Our lower mortality (11.7% after emergency surgery) may reflect differences in case-mix and access to critical care.

Operations lasting more than 4 hours were followed by complications in every case. Longer operations reflect technical complexity, contamination and physiological stress. Operative duration is partly modifiable through senior involvement and early conversion decisions.

Comorbidity raised the odds of complications three-fold, and age above 60 years 2.6-fold. Both reflect reduced physiological reserve and argue for preoperative optimisation and geriatric assessment where time allows.

Abnormal preoperative laboratory values were common among patients who developed complications. Hypoalbuminaemia (< 2.5 g/dL) was the strongest laboratory marker (70% complication rate). This is consistent with the established link between malnutrition and wound and anastomotic failure. ESPEN guidelines recommend nutritional screening and support before major surgery [20]. Many of our emergency patients could not be optimised before surgery. In elective patients, however, correcting anaemia, hypoalbuminaemia and electrolyte disturbances is an achievable target. Enhanced recovery pathways that include these measures reduce complications [21].

Laparoscopic surgery carried fewer complications than open or converted procedures (20.0% vs 48.9% and 46.7%). This result should be read with caution. All laparoscopic procedures were elective, so the difference largely reflects patient selection rather than an effect of the approach itself. Kokotovic et al. found that approach was not independently associated with severe complications after adjustment [18].

V. IMPLICATIONS

Routine Clavien-Dindo grading at discharge would allow surgical units in Indian public hospitals to audit morbidity in a standard way and compare it over time and with other centres. In our cohort, simple risk markers (emergency status, ASA III/IV, comorbidity, age > 60 years and expected long operations) identified a high-risk group. These patients could be prioritised for senior-led surgery, high-dependency monitoring and early escalation, which are the main ways to prevent failure to rescue [4].

VI. STRENGTHS AND LIMITATIONS

The strengths of this study are its prospective design, consecutive enrolment, complete follow-up and use of a validated grading system. It also comes from a public-sector setting that is under-represented in the literature. It has several limitations. It was a single-centre study with a modest sample, and the procedures were heterogeneous, which limits subgroup analyses. Follow-up ended at discharge, so complications after discharge within 30 days may have been missed. Laboratory values were analysed as normal or abnormal rather than as continuous measures, and we did not use a composite risk score such as POSSUM or the ACS-NSQIP calculator [22]. We reported only the

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highest grade per patient, and the Comprehensive Complication Index would capture the cumulative burden more fully [9].

Finally, the observational design means the associations identified are not causal.

VII. CONCLUSION

Two in five patients developed a complication after major abdominal surgery in this Indian tertiary care hospital. Most complications were Clavien-Dindo Grade I–II, but one-third of complicated patients needed re-intervention or organ support, or died. ASA III/IV, operations lasting more than 4 hours, emergency surgery, comorbidity and age above 60 years independently predicted complications. The Clavien-Dindo classification was simple to apply, and its grades tracked length of stay. We recommend its routine use for morbidity audit, together with early risk stratification and preoperative optimisation of high-risk patients.

DECLARATIONS

- Ethical approval: The Institutional Ethics Committee, P.D.U. Government Medical College, Rajkot, approved this study (PDUMCR/IEC/325/2024, dated 30 October 2024).
- Consent: Every patient, or a legally authorised representative, gave written informed consent to participate and for anonymised data to be published.
- Sources of funding: None.
- Author contributions: MN: study concept and design, data collection, data analysis and interpretation, and writing of the manuscript. JGB: study concept, supervision, critical revision of the manuscript and final approval. [Edit to match the final author list.]
- Conflicts of interest: The authors declare no conflicts of interest.

- *Research Registration Unique Identifying Number (UIN):*

✓ Name of the registry: [Research Registry / CTRI]
✓ Unique identifying number or registration ID: [to be added]
✓ Hyperlink to the registration: [to be added]

- Guarantor: Dr Manisha Nakum and Dr Jatin G. Bhatt.
- Provenance and peer review: Not commissioned, externally peer-reviewed.
- Data availability statement: De-identified data are available from the corresponding author on reasonable request.
- Declaration on the use of AI: An AI writing assistant (Claude, Anthropic) was used to help structure and edit this manuscript from the authors' thesis. The authors reviewed and verified all content and take full responsibility for it.

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TABLES

Table 1 Baseline and Operative Characteristics (n = 150)

Characteristic	n (%)
Age group (years)	
17–30	24 (16.0)
31–40	28 (18.7)
41–50	36 (24.0)
51–60	38 (25.3)
> 60	24 (16.0)
Mean age ± SD (years)	48.6 ± 15.2
Sex	
Male	92 (61.3)
Female	58 (38.7)
Comorbidity[a]	
Any comorbidity	90 (60.0)
Hypertension	36 (24.0)
Diabetes mellitus	30 (20.0)
COPD	10 (6.7)
Chronic liver disease	9 (6.0)
Coronary artery disease	8 (5.3)
Chronic kidney disease	3 (2.0)
Others	6 (4.0)
ASA grade	
I	36 (24.0)
II	62 (41.3)
III	40 (26.7)
IV	12 (8.0)
Urgency	
Elective	90 (60.0)
Emergency	60 (40.0)
Procedure group	
Emergency laparotomy	60 (40.0)
Hepatobiliary	30 (20.0)
Gastrointestinal	25 (16.7)
Pancreatic	15 (10.0)
Splenic	10 (6.7)
Radical nephrectomy	8 (5.3)
Others	2 (1.3)
Surgical approach	
Laparoscopic	45 (30.0)
Open	90 (60.0)
Laparoscopic converted to open	15 (10.0)
Operative duration	
< 2 h	42 (28.0)
2–4 h	74 (49.3)
> 4 h	34 (22.7)
Mean ± SD (h)	3.1 ± 1.2

[a] Patients could have more than one Comorbidity. COPD, Chronic Obstructive Pulmonary Disease; ASA, American Society of Anesthesiologists.

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Table 2 Complication Type, Clavien-Dindo Grade and Length of Stay (Complicated Patients, n = 60)

Variable	n (%)	Mean hospital stay (days)
Type of complication[a]		
Surgical site infection	16 (26.7)	
Postoperative ileus	10 (16.7)	
Pulmonary complications	8 (13.3)	
Anastomotic leak	6 (10.0)	
AKI with septic shock	6 (10.0)	
Intra-abdominal collection	5 (8.3)	
Haemorrhage	4 (6.7)	
Urinary tract infection	3 (5.0)	
Deep vein thrombosis	2 (3.3)	
Multi-organ failure	2 (3.3)	
Clavien-Dindo grade		
I	14 (23.3)	6.8
II	22 (36.7)	9.2
IIIa	7 (11.7)	13.4
IIIb	8 (13.3)	16.8
IVa	4 (6.7)	21.7
IVb	2 (3.3)	25.5
V	3 (5.0)	—

[a]Percentages are of the 60 Complicated Patients. Some Patients had more than One Complication. AKI, Acute Kidney Injury.

Table 3 Univariable Association of Patient, Operative and Laboratory Factors with Postoperative Complications

Factor	Complications present, n (%)	Complications absent, n (%)	p-value
Age group (years)			0.003
17–30 (n = 24)	5 (20.8)	19 (79.2)	
31–40 (n = 28)	8 (28.6)	20 (71.4)	
41–50 (n = 36)	12 (33.3)	24 (66.7)	
51–60 (n = 38)	18 (47.4)	20 (52.6)	
> 60 (n = 24)	17 (70.8)	7 (29.2)	
Comorbidity			< 0.001
Present (n = 90)	50 (55.6)	40 (44.4)	
Absent (n = 60)	10 (16.7)	50 (83.3)	
Urgency			< 0.001
Emergency (n = 60)	40 (66.7)	20 (33.3)	
Elective (n = 90)	20 (22.2)	70 (77.8)	
ASA grade			< 0.001
I (n = 36)	6 (16.7)	30 (83.3)	
II (n = 62)	18 (29.0)	44 (71.0)	
III (n = 40)	24 (60.0)	16 (40.0)	
IV (n = 12)	12 (100)	0 (0)	
Procedure group			< 0.001
Emergency laparotomy (n = 60)	40 (66.7)	20 (33.3)	
Hepatobiliary (n = 30)	8 (26.7)	22 (73.3)	
Pancreatic (n = 15)	4 (26.7)	11 (73.3)	
Gastrointestinal (n = 25)	6 (24.0)	19 (76.0)	
Radical nephrectomy (n= 8)	1 (12.5)	7 (87.5)	
Splenic (n = 10)	1 (10.0)	9 (90.0)	
Others (n = 2)	0 (0)	2 (100)	
Surgical approach			0.005
Laparoscopic (n = 45)	9 (20.0)	36 (80.0)	
Open (n = 90)	44 (48.9)	46 (51.1)	
Converted to open (n = 15)	7 (46.7)	8 (53.3)	
Operative duration			< 0.001
< 2 h (n = 42)	6 (14.3)	36 (85.7)	
2–4 h (n = 74)	20 (27.0)	54 (73.0)	
> 4 h (n = 34)	34 (100)	0 (0)	
Abnormal preoperative			

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investigation			
Haemoglobin (n = 40)	25 (62.5)	15 (37.5)	< 0.001
Total leucocyte count (n = 50)	30 (60.0)	20 (40.0)	< 0.001
Serum creatinine (n = 28)	18 (64.3)	10 (35.7)	0.004
Serum bilirubin (n = 23)	15 (65.2)	8 (34.8)	0.007
Serum albumin < 2.5 g/dL (n = 40)	28 (70.0)	12 (30.0)	< 0.001
PT-INR > 1.6 (n = 29)	20 (69.0)	9 (31.0)	< 0.001
Hyponatraemia (n = 36)	22 (61.1)	14 (38.9)	0.003
Hypokalaemia (n = 28)	18 (64.3)	10 (35.7)	0.004

Chi-Square Test; Fisher's Exact Test where Expected Counts were below 5. Percentages are Row Percentages.

Table 4 Multivariable Logistic Regression for Predictors of Postoperative Complications

Variable	**Adjusted OR**	**p-value**
ASA grade III/IV	5.0	< 0.001
Operative duration > 4 h	4.5	< 0.001
Emergency surgery	4.2	< 0.001
Comorbidity	3.1	0.002
Age > 60 years	2.6	0.012

OR, odds Ratio. [Add 95% Confidence Intervals from the SPSS Output.]