

Relationship Between Hemoglobin Levels, *Index Severity Score*, Leukocytes and Degree of Open Fracture with Surgical Complications (*Clavien Dindo Classification*) in Long Bone Open Fracture Patients with External Fixation and Internal Fixation at Prof. IGNG Ngoerah Hospital

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ABSTRACT

Introduction: Open bone fractures are an emergency case in the field of orthopedics that must be treated quickly because of its significant morbidity and mortality. Several parameters and classifications are used to assess the impact severity of one open bone fracture. There is no study that has discussed the comparison of each parameter yet. Aims of this study to determine the relationship between hemoglobin levels, injury severity score, leukocytes and the degree of open fracture with the outcome of long bone open fracture patients who are carried out external and internal fixation installation surgery and measured through the degree of Clavien Dindo .

Methods: This research was carried out at RSUP Prof I.G.N.G. Ngoerah, Denpasar, Bali with research time from May 2023 to December 2023. Clinical and laboratory data were obtained from secondary data from patient medical records. Data analysis in research uses descriptive analysis and inferential analysis.

Results: In this study, a sample of 32 patients was obtained with more males than females with percentages of 65.6% and 34.4%. Based on age, the average is 31 years with the youngest being 16 years and the oldest being 58 years. The Hemoglobin level and leukocyte respectively have an average of 8.51 and 17.7 with score of Gustilo Anderson and ISS 2.73 and 10.06. The results of this study showed a significant relationship ($p < 0.05$) with hemoglobin $p = 0.525$, leukocytes $p = 0.01$, Gustilo Anderson $P = 0.028$ and ISS $p = 0.022$ to the classification of Clavien Dindo .

Conclusion: The conclusion of this study is that the Clavien-Dindo has a relationship with several factors such as hemoglobin, leukocyte, ISS and Gustilo Anderson which can affect patient condition.

Keywords: Open Fracture, Clavien Dindo , Hemoglobin, Leukocyte, Index Severity Score, Gustilo Anderson

INTRODUCTION

Open bone fracture is an emergency case in the orthopedic field that must be treated

quickly to prevent infection or failure to heal the bone itself. An open fracture can be defined as a fracture that communicates with the outside environment through soft tissue injuries. Most open fractures occur in long bones. The incidence of open fractures is much higher in developing countries, where traffic accidents and workplace accidents are common and tend to increase every day. Globally, in 2019, there were 178 million fracture cases (an increase of 33.4% since 1990) (Wu et al., 2021). An open fracture is a serious orthopedic injury that can cause significant patient morbidity and mortality.

The Clavien–Dindo classification (CDC) is a standardized system for assessing the degree of complications that assess the negative effects of surgical complications with key characteristic of the CDC system is that the severity of complications is assessed based on the type of therapy needed to treat complications. There are 4 grades from the CDC, namely grade 1 (postoperative changes with complete recovery), grade 2 (all types of complications that may be life-threatening), grade 3 (any complications with residual or prolonged functional disability), and grade 4 (complications requiring replantation). (Miyamoto et al., 2019).

Parameters referring to hemodynamic instability and multiple organ disorders may indicate a poor prognosis (complication) for open fractures, including hemoglobin, and base excess (BE) (Ashton Acton, 2013). Injury Severity Score (ISS) is one of the commonly used methods in the medical world to evaluate the severity of physical injury in a person who has experienced trauma or accident based on injuries that occurred to several different parts of the body. Leukocytes are an integral part of the immune system responsible for protecting the body from infection and inflammation. The involvement of leukocytes in fractures or fractures is often the focus of research because of their important role in the

healing process and the body's response to injury.

Until now there are still no studies that discuss the relationship of Dindo Clavien with other parameters such as Hb examination, *international normalized ratio*, *injury severity score*, leukocytes and degree of open fracture with the outcome of long bone open fracture patients who are surgically installed external and internal fixation

This study aimed to determine the relationship between hemoglobin examination, *injury severity score*, leukocytes and the degree of open fracture with the outcome of long bone open fracture patients who are carried out external and internal fixation installation surgery and measured through the degree of clavien Dindo .

METHODS

Study Design

This study employed a cross-sectional design analytical observational study. Patients with lumbar canal stenosis was assessed. The data obtained from the research is analyzed as follows: Firstly, a descriptive analysis is conducted to provide an overview of the data. Secondly, an inferential analysis is performed, which includes a testing the normality of the data distribution using the Shapiro-Wilk test to determine whether the data follows a normal distribution. Conducting Pearson correlation test if the data is normally distributed, and Spearman correlation test if the data is not normally distributed. These analyses aim to explore relationships and patterns within the data, allowing for a comprehensive understanding of the research findings. The target population include all open fracture patients undergoing surgery in the perating Room of the Emergency Department of RSUP Prof. Dr. I.G.N.G. Ngoerah Denpasar with age between 17 - 65 years. The Onset of trauma should be ≤ 24 hours and patients agreed to be sampled in this study.

Consecutive sampling was utilized until the sample size was achieved.

This study included participants open fracture patients undergoing surgery in the operating Room of the Emergency Department of RSUP Prof. Dr. I.G.N.G. Ngoerah Denpasar and had their data stored in the medical records of RSUP Prof Dr I G N G Ngoerah Denpasar between May 2023 and December 2024. The research procedure involves initially searching for research samples from medical records, specifically targeting patients diagnosed with open fracture. Following patient selection, measurements of index severity score, Clavien-Dindo and Gustilo Anderson are taken, and laboratory examinations for hemoglobin and leukocytes are conducted. Finally, data analysis is performed to derive insights from the collected information.

Data Collection

The data collection method for this study was conducted systematically. Initially, the research was conducted at RSUP Prof. I G.N.G. Ngoerah, Denpasar, Bali. Clinical and laboratory data were obtained from secondary data from patient medical records, and selected through inclusion and exclusion criteria. Contact details of potential subjects were obtained and used to communicate the research procedures and seek their willingness to participate via telephone or chat applications. measurements of index severity score, Clavien-Dindo and Gustilo Anderson are taken, and laboratory examinations for hemoglobin and leukocytes are conducted. Finally, data analysis is performed to derive insights from the collected information.

STATISTICAL ANALYSIS

The data obtained in the study were subjected to two main types of analysis. Firstly, descriptive analysis was conducted to summarize and describe the characteristics of the data. Secondly, inferential analysis was performed, which involved two steps. Initially, the normality

of the data distribution was assessed using the Shapiro-Wilk test. If the data were normally distributed, the Pearson Correlation Test was applied to examine correlations between variables. Alternatively, if the data were not normally distributed, the Spearman Test was used instead. These analyses were crucial in understanding the relationships and patterns within the data, providing valuable insights into the research findings.

Furthermore, a Spearman correlation analysis was conducted to examine the relationship between the Clavien Dindo and score of Gustilo Anderson and ISS. Pearson correlation analysis conducted to analyze relation between Clavien Dindo and hemoglobin and Leukocyte. Based on the analysis conducted, a significant relationship with p-value ($p < 0.05$). If the study confirms a positive relationship between HLF and IL-10 levels, IL-1 β , and VAS the implications could be significant in a clinical context. Regression analysis was also conducted in this study. This understanding may help pave the way for the development of therapies.

RESULTS

A. Research Subject Characteristics

In this study, a sample of 32 patients was obtained with more males than females with percentages of 65.6% and 34.4%. Based on age, the average is 31 years with the youngest being 16 years and the oldest being 58 years.

Table 1 Sample Distribution on Sex

Sex	Total	Percentage
Men	21	65.6 %
Women	11	34,4 %

Table 2 Sample Distribution based on Age

Characteristic	Age
Age Range	16 - 58 year
Mean \pm SD	31 \pm 8.60year

B. Inferential Analysis

The spearman, Pearson correlation test and regression test were used to evaluate the

relationship between hemoglobin, levels, ISS, leukocytes and Gustilo Anderson degree to the classification of Clavien Dindo Significant correlation coefficient value ($p < 0.05$). The results of this study showed a significant relationship in hemoglobin, leukocytes, Gustilo Anderson and ISS to the classification of Clavien Dindo.

Table 3 Spearman Correlation analysis for Gustilo Anderson and ISS score to Clavien Dindo

Variable	Variable	Correlation Coefficient	P Value
Gustilo Anderson	Clavien Dindo	0,388	0,028
ISS	Clavien Dindo	0,698	0,022

Table 4 Pearson Correlation Analysis for Clavien Dindo with Leukocytes and Hb Levels

Variable	Variable	Correlation Coefficient	P Value
Hemoglobin	Clavien Dindo	-0,715	0,525
Leucocyte	Clavien Dindo	0,066	0,01

Under each analysis the results of this study showed a significant relationship ($p < 0.05$) with hemoglobin $p = 0.525$, leukocytes $p = 0.01$, Gustilo Anderson $P = 0.028$ and ISS $p = 0.022$ to the classification of Clavien Dindo

DISCUSSION

A. Relationship between hemoglobin (Hb) and Dindo Clavien grade patients with open fractures of long bones performed external and internal fixation installation surgery

The results of the study of Camino Willhuber et al. showed that Hemoglobin (Hb) is associated with Dindo Clavien degrees in patients with open fractures of long bones who were surgically with external and internal fixation. This is consistent with several other studies. In one study that examined the average 90-day postoperative complications reached 28.7% based on the classification of Dindo Clavien. The most common postoperative

complications are pain, infection, and anemia. Two-thirds of these complications are minor with Dindo Clavien classification 1, II, IIIA (Camino Willhuber et al., 2019).

A retrospective study from Willhuber et al. on postoperative complications in orthopaedic department patients found 159 patients with complications of Dindo Clavien type 2 where the most frequent was symptomatic anemia of 42.1% (67/159) followed by infections requiring antibiotics of 16.9% (27/159), urinary tract infections of 10% (16/159) (Willhuber et al., 2018b).

Anemia is related to the degree of Dindo Clavien. This is due to excessive bleeding leading to postoperative anemia where requiring a transfusion is the most common non-surgical complication. In addition, significant differences were also found in postoperative hemoglobin.

Patients with complications show lower hemoglobin values compared to those without complications. Excessive bleeding may be associated with complications and increased length of hospital stay (LOS). Low levels of hemoglobin are linked to delayed wound healing, especially when combined with risk factors such as low oxygen, older age, diabetes, obesity, alcoholism, smoking, and poor nutritional status. These factors are important for determining the patient's susceptibility index (Camino-Willhuber et al., 2023).

Fractures in long bones can provide massive bleeding and are difficult to control, because vascularization is large, but small in size, so that in operative measures, other than fracture reduction and fixation, there is no definitive action of bleeding control, such as cauterization or *bone wax application*. This heavy bleeding, of course, will have an impact on the patient's hemoglobin level, which when it reaches a certain level requires a blood transfusion, thereby increasing the degree of Dindo Clavien of the patient.

B. The relationship between the degree of open fracture and Dindo Clavien grade

of long bone open fracture patients who have external and internal fixation installation surgery.

From the study of Müller et al. found no relationship between the degree of open fracture and Dindo Clavien grade of long bone open fracture patients who were surgically fitted with external and internal fixation. Until now, there have been no studies that directly assess the relationship of fracture classification with Dindo -Clavien. However, there are several other related studies where it was found that Gustilo Anderson's classification was not associated with soft tissue reconstruction failure ($p = 0.739$), non-union fracture ($p = 0.282$), or recurrent infection ($p = 0.549$) (Müller et al., 2021).

However, another study from JYC et al. found that fractures with Gustilo-Anderson type III were three times more likely to develop infection ($p = 0.007$) and complications ($p = 0.015$) than type I or II. However, this study did not individually analyze other factors that corresponded such as fracture time to surgery, length of surgery, patient comorbidities, ASA status, and others. Thus, the relationship between the degree of open fracture and *Dindo Clavien grade* of long bone open fracture patients who are surgically fitted with external and internal fixation is still inconclusive and requires further research (JYC et al., 2017).

The study found a significant association between the degree of open fracture and Dindo Clavien grade in long bone open fracture patients undergoing external and internal fixation installation surgery. Although no studies have directly explored the correlation of fracture classification with Dindo -Clavien, several related studies note that Gustilo Anderson classification has no association with soft tissue reconstruction failure, nonunion fractures, or recurrent infections. Other findings suggest that fractures with degree III Gustilo-Anderson have a higher risk of developing complications compared to grade I or II.

Therefore, the correlation between the degree of open fracture and Dindo Clavien grade in long bone open fracture patients undergoing external and internal fixation installation surgery still requires further research to obtain more in-depth conclusions

C. The relationship between leukocytes and Dindo Clavien grade patients with open fractures of long bones performed external and internal fixation installation surgery.

From the study of Inose et al. obtained a relationship between lymphocytes and Dindo Clavien grade long bone open fracture patients who were performed external and internal fixation installation surgery. Neutrophils are an important factor in bioprotection against bacterial infections whereas lymphocytes are an important factor in nonspecific bioprotection. Characteristic of the initial stage of infection is an increase in the number of neutrophils and a decrease in the number of lymphocytes (Inose et al., 2020).

This is evidenced by several studies from Schroth et al. the condition of lymphopenia when preoperative is associated with a threefold increase in mortality rates (*Risk ratio* (RR) = 3.22; *confidence interval* 95% (CI) = 2.19–4.72; $P < 0.01$, $I^2 = 0\%$) and more frequent major postoperative complications (RR=1.33; CI 95%, 1.21–1.45; $P < 0.01$, $I^2 = 6\%$), including cardiovascular morbidity (RR=1.77; CI 95%, 1.45–2.15; $P < 0.01$, $I^2 = 0\%$), infection (RR=1.45; CI 95%, 1.19–1.76; $P < 0.01$, $I^2 = 0\%$), and acute renal dysfunction (RR=2.66; CI 95%, 1.49–4.77; $P < 0.01$, $I^2 = 1\%$) (Schroth et al., 2021).

Leukocytes and the degree of open fracture have been associated with surgical complications in patients with open fractures of long bones. Elevated leukocytes, especially preoperative, can be a sign of infection, inflammation, or trauma, and are the biggest predictor of surgical complications. A higher degree of open fracture indicates more severe soft tissue

damage, and is also associated with an increased risk of surgical complications. Research shows that preoperative leukocytosis and degree III open fracture are risk factors for surgical complications such as infection, wound dehygiensia, and osteomyelitis. Management of open fracture patients should consider these risk factors to minimize complications (Paladino et al., 2010).

A study from Hong et al. involving 199 patients aged >65 years who underwent hip fracture surgery under general anesthesia found that the most common postoperative complication was respiratory complication. Compared with patients who did not experience postoperative complications, patients with postoperative complications had significantly higher NLRs (8.01 ± 4.70 vs. 5.12 ± 4.34 , $p < 0.001$) (Hong et al., 2022).

The fracture produces an inflammatory response in which the severity is proportional to the degree of tissue damage surrounding the tissue. It also depends on the patient's immune status. Studies by Chen et al. have shown that perioperative inflammatory responses are associated with postoperative complications, regardless of patient and surgical factors. In addition, the inflammatory response can predict postoperative complications during hospital treatment (Chen et al., 2016).

This study proved a relationship between lymphocytes and Dindo Clavien grade in long bone open fracture patients undergoing external and internal fixation installation surgery. Neutrophils and lymphocytes, as bioprotective factors, play an important role in the response to infection. Several studies support these findings, suggesting that the condition lymphopenia before surgery is associated with a threefold increased risk of death and major postoperative complications, including cardiovascular morbidity, infection, and acute renal dysfunction. A deep understanding of the role of lymphocytes in perioperative inflammatory response is indispensable in

managing long bone open fracture patients undergoing external and internal fixation installation surgery

D. The relationship between the Injury Severity Score (ISS) and Dindo Clavien Grade of long bone open fracture patients who underwent external and internal fixation installation surgery.

From this study, a relationship was obtained between *the Injury Severity Score* (ISS) score and Dindo Clavien grade of long bone open fracture patients who were carried out external and internal fixation installation surgery. This is consistent with several other studies. A study whose sample had a median ISS value of 25 (16-34) found that patients who experienced trauma-related complications had higher median ISS scores compared to those who did not experience complications (30 vs 21; $p < 0.001$). Patients in the ICU group had higher median ISS scores (26) compared to those in the non-ICU group (15); $P < 0.001$. The most severely injured patients with hemorrhagic shock had significantly higher ISS scores, different injury patterns, and different distribution of Dindo Clavien scores (Naumann et al., 2017).

Studies from Banerjee and Moran et al. with samples that have a median value of ISS 13 (9-22) also show similar results. ISS, NISS, and Revised Trauma Scores were also found to be better in patients without any complications. According to a ten-year study of Banerjee and Moran et al. from NHS hospitals, patients with $ISS \geq 9$ had an overall mortality of 8.3% among 248,234 samples. The study included 381 of 505 patients with $ISS \geq 9$ and mortality among them was 10.5%. With such an ISS score, 257 out of 505 patients did not experience any complications. When looking at Dindo Clavien's ranks, degrees I (15.6%) and degree II (9.3%) are the most degrees followed by degrees III (8.2%) and IV (7.7%) (Banerjee et al., 2022; Moran et al., 2018).

This study revealed a significant association between Injury Severity Score (ISS) and Dindo Clavien grade in long bone open fracture patients undergoing external and internal fixation installation surgery. ISS scores also correlate with Dindo Clavien degrees, where patients with high ISS scores tend to have higher degrees, especially in degrees I and II. This indicates that the severity of injury, as measured by the ISS, may be an important predictor in evaluating the risk of complications and the clinical degree of patients with open fractures of long bones after external and internal fixation surgery.

From this study, it was found that leukocytes were the parameter most associated with Clavien Dindo ($R = 0.728$ $p = 0.000$ category = high), followed by hemoglobin ($R = -0.715$ $p = 0.000$ category = high), ISS ($R = 0.698$ $p = 0.000$ category = high), and Gustilo Anderson ($R = 0.388$ $p = 0.028$ category = very low). This may be because the leukocyte and hemoglobin parameters stand alone, while the ISS and Gustilo Anderson scores are a collection of several other parameters so that the risk factor can be higher.

CONCLUSION

Surgical complications (Clavien-Dindo) are influenced by a number of factors. Hemoglobin and leukocytes, along with the Injury Severity Score and degree of open fracture, can be used as a benchmark to evaluate possible surgical complications. However, keep in mind that the final decision regarding the risk of complications should be based on a thorough understanding of the combination of all factors involved. Hemoglobin and leukocytes give an idea of the patient's hematological condition, while the Injury Severity Score and degree of open fracture cover other aspects involving various factors. By considering all these factors together, a more comprehensive understanding of the risks of surgical complications can be achieved

Declaration by Authors

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