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# CLINICAL ARTICLE

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## Predictive values of serum nutritional indices for early postoperative wound infections in surgically treated closed femoral fractures

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### Abstract

#### Background

Laboratory assessments of nutritional status consisting of evaluation of serum albumin and total lymphocytes count (TLC) are valid tests of a patient's nutritional status. This study evaluated these indices and the findings were correlated with the occurrence of early surgical site infection (SSI).

#### Methods

This was a prospective study conducted on 100 patients with closed femoral fractures for a period of ten months. Blood samples were taken to determine levels of serum albumin, total lymphocytes count and for human immunodeficiency virus (HIV). Postoperatively, body mass index (BMI) was calculated and wounds were examined regularly for signs of SSI.

#### Results

On the basis of the albumin index, 25% of the patients had malnutrition and the infection rate in this group was 28%. Malnutrition as per TLC was 3% with an infection rate of 33.3%. Only one patient was malnourished when both albumin and TLC indices were considered and this patient developed SSI. Risk of developing SSI was about 10 times in those with albumin depletion, four times in those with reduced TLC and 12 times when both indices were low. Significant association was seen in low albumin levels ( $P = 0.000$ ).

#### Conclusions

Patients at risk of SSI can be identified pre-operatively using relatively inexpensive laboratory tests of nutritional parameters such as serum albumin. Preventive measures like nutritional support and prophylactic antibiotics can then be initiated.

## Introduction

Trends towards changing the management of fractures of the shaft of femur advocate operative treatment as it facilitates early ambulation and reduced length of hospital stay.<sup>1</sup> However there are situations where ambulation and discharge of the patient is delayed due to surgical site infection (SSI), which in one way or another may be related to sub-clinical or clinical malnutrition. The reported infection rate among the malnourished ranges from 7.6 % to 14.6 % depending on severity.<sup>2</sup> Resultant increased hospital stay due to SSI has been estimated at 7–10 days, increasing hospitalisation costs by 20%.<sup>3</sup> One can determine the nutritional status of a patient by using a variety of assessments, like anthropometric measurements, biochemical assessment and immunological assessment. Studies in geriatric patients have reported a high incidence of subclinical malnutrition in patients undergoing orthopaedic surgical procedures by analysing two biochemical indices: serum albumin and total lymphocytes count (TLC).<sup>4</sup> Other factors which can influence the occurrence of SSI include HIV status, obesity, operation time, surgical technique, soft tissue handling and maintenance of aseptic technique. This study focused on the possibility of predicting early postoperative wound infections using serum albumin levels and TLC. Such nutritional indices can be measured easily and cost effectively in our environment where resources are limited and may be used to complement the national nosocomial infection surveillance system (NNIS) of the CDC (1996) which is the risk index currently in use.<sup>5</sup>

## Materials and methods

A prospective study was conducted from March to December on patients aged 13 years and above who had closed femoral shaft fractures and were operated within a week from when the injury was sustained. A total of 100 patients were recruited after applying the Kirkwood formula for the sample size at a significance level of 95%, the proportion of malnourished patients with femoral shaft fractures was 58.6%<sup>6</sup> and the margin of error was 10%. Patients excluded from the study were those operated after a week from when the injury was sustained, those with bilateral femoral fractures, polytrauma patients, and patients with any of the following co-morbid condition(s): diabetes, cancer, vasculopathy, connective tissue disorder, nephropathy, hepatic disorder or systemic infection.

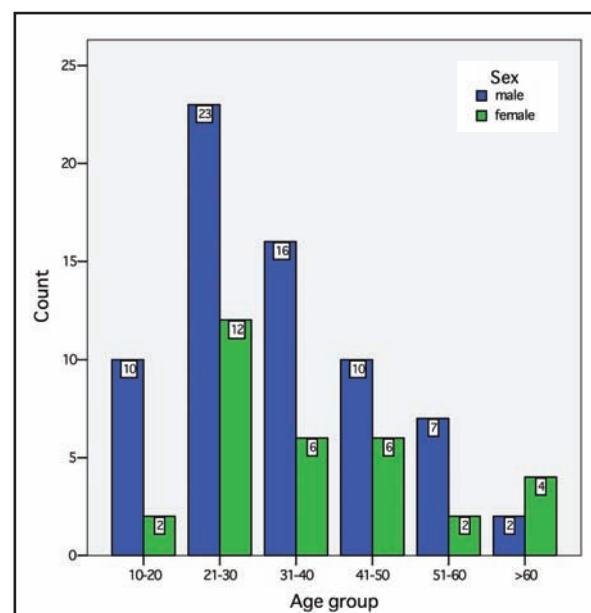
The operation site was inspected pre-operatively for signs of skin infection. About 3 ml of blood was drawn from all eligible patients to determine levels of serum albumin, TLC and for HIV. Open reduction and internal fixation operations were performed by trauma surgeons who were also involved in the confirmation of the type of fracture according to the X-ray films. All patients had their operations done in the same theatre which was equipped with laminar flow, and similar standardised protocols were followed.

Ceftriaxone injections at a dose of 1 gram once daily for three days were prescribed. The first dose was given within 24 hours postoperatively. Assessment for surgical wound status was done daily from the third postoperative day when in-patient, and once per week after discharge. This follow-up continued for the first 30 postoperative days; and diagnosis for the presence of infection was based on the Centre for Disease Control (CDC) criteria. Neither culture nor Gram staining was done; the finding of a purulent discharge at the operation site was considered the determinant for the presence of infection. Malnutrition was considered to exist when a patient had values of serum albumin of < 3.5 g/dl and/or TLC < 1 500 cells/ml. The rapid method for HIV testing was used. The initial negative results were considered negative while positive results were repeated with the same rapid method. Negative results for the second test were concluded as negative and positive results as positive. Height and weight measurements were taken as soon as the patient started to ambulate while still being an in-patient and the body mass index (BMI) was calculated. A BMI of less than 18.5 was regarded as underweight, while a BMI of greater than 24.9 was considered overweight and above 29.9 obese.

All eligible patients gave written consent for their participation and ethical clearance was obtained from the research and publication committee of the local university.

## Statistics

The Chi-square test was applied to check for the associations where statistical significance was accepted for  $p < 0.05$ . The risk for infection in malnourished individuals was identified by a relative risk of greater than 1.



**Figure 1.** Distribution of patients by age groups (years) and sex

**Table I: Distribution of patients according to fracture type and implant used**

Implant	Fracture type		Total
	Simple	Comminuted	
K-wires	1 (1.0%)	0	1 (1.0%)
UFN	38 (38.0%)	7 (7.0%)	45 (45.0%)
DCP	23 (23.0%)	31 (31.0%)	54 (54.0%)
Total	62 (62.0%)	38 (38.0%)	100

**Results**

All 100 patients who were followed up had a mean age of 36.11 years with a standard deviation of 14.38. The oldest patient was 77 years old and the youngest was 13 years old. The peak age group was 21–30 years accounting for 35.0% of the study population. The age group above 60 years accounted for the least number of patients (6.0%). There were 68 males and 32 females, giving a male to female ratio of approximately 2:1 (Figure 1).

Forty patients (40.0%) had mid-shaft fractures; 28 patients (28.0%) had fractures of the proximal third and 32 patients (32.0%) had distal third fractures.

Fractures with comminution were seen in 38 patients (38.0%); and the rest were simple fractures. Of all the

patients, plating with a broad dynamic compression plate (DCP) was done in 54 patients (54.0%) and nailing by open method using universal femoral nails (UFN) in 45 patients (45.0%). A boy with a supracondylar fracture was managed with crossing Kirschner wires (K-wires) (Table I).

Seventeen males (25.0%) and 8 females (25.0%) were malnourished as per the albumin parameter. Considering the lymphocytes count criteria, there were 2 males and 1 female. The highest percentage of malnutrition occurred in the age group > 60 years according to albumin values and age group 21–30 years based on lymphocytes count (Table II).

On average albumin levels in patients who developed wound infection were low (mean 3.1 g/dl, std deviation 0.56) compared to those who had no wound infection (mean 3.9 g/dl, std deviation 0.56). To the contrary, lymphocyte counts in patients who developed wound infection averaged higher (mean 2 641.0 cells/ml, std deviation 582.39) than in those without wound infection (mean 2 587.8 cells/ml, std deviation 687.93).

**This study focused on the possibility of predicting early postoperative wound infections using serum albumin levels and TLC indices which can be measured easily and cost effectively**

**Table II: Distribution of patients according to age groups and levels of nutritional indices**

Age groups (yrs)	Nutritional indices			
	Albumin (g/dl) N = 100		TLC (cells/ul) N = 100	
	< 3.5	3.5 or more	< 1 500	1 500 or more
10–20	3 (25.0%)	9 (75.0%)	0	0
21–30	6 (17.1%)	29 (82.9%)	2 (5.7%)	0
31–40	6 (27.3%)	16 (72.7%)	1 (4.5%)	0
41–50	6 (37.5%)	10 (62.5%)	0	33 (94.3%)
51–60	1 (11.1%)	8 (88.9%)	0	21 (95.5%)
> 60	3 (50.0%)	3 (50.0%)	0	16 (100.0%)
				9 (100.0%)
				6 (100.0%)
<b>Total</b>	<b>25 (25.0%)</b>	<b>75 (75.0%)</b>	<b>3 (3.0%)</b>	<b>97 (97.0%)</b>

**Table III: Association between levels of nutritional indices and wound infection**

	Albumin (g/dl) N=100		TLC (cells/ml) N=100		Both indices low N=100	
	< 3.5 (n=25)	3.5 or > (n=75)	<1500 (n=3)	1500 or > (n=97)	yes (n=1)	No (n=99)
	Wound infection					
yes (n=9)	7 (28.0%)	2 (2.7%)	1 (33.3%)	8 (8.2%)	1 (100.0%)	8 (8.1%)
no (n=91)	18 (72.0%)	73 (97.3%)	2 (66.7%)	89 (91.8%)	0	91 (91.9)
Chi-square	14.693		2.236			
P-value	0.000		0.135			
Degree of freedom	1		1			
Relative risk	10.37 (28/2.7)		4.06 (33.3/8.2)		12.35 (100/8.1)	

Out of 25 patients who had an albumin level  $< 3.5$ g/dl, seven patients (28.0%) acquired wound infection. Patients with low albumin had a 10 times increased risk of developing wound infection, and the association found was significant ( $P=0.000$ ). Of the three patients who had lymphocytes count  $< 1\ 500$  cells/ul, one patient developed wound infection. The risk of getting wound infection with low TLC was 4 times, but the association was not statistically significant ( $P=0.135$ ). The only patient who had both albumin and TLC low developed wound infection. The risk of developing wound infection with an albumin  $< 3.5$  g/dl and a TLC  $< 1\ 500$  cells/ul was 12 times higher. (Table III).

There were 8(8%) HIV-infected patients. Of these, only 1 patient developed wound infection. The association found was not significant ( $P = 0.718$ ). About half of the study population had normal weight (52%) and the infection rate in this group was 7.7% (4 patients). Underweight and overweight accounted for 26 (26%) and 17 (17%) patients respectively, with an infection rate of 15.4% (4 patients) in the underweight group and 5.9% (1 patient) in the overweight group. There were 5 obese patients and none of them developed wound infection. The association found was not statistically significant ( $P = 0.552$ ).

There was no significant association between operation time and occurrence of wound infection ( $P = 0.576$ ). Forty-four patients, who were in the majority, were operated within the interval of 61–90 minutes. Wound infection in this time interval occurred in five patients (11.4%). Most wound infections occurred in the interval of 91–120 minutes where out of 21 patients, 3 patients (14.3%) developed wound infection.

## Discussion

In developing countries malnutrition is a major concern and is one of the most difficult problems to solve. It is not only a medical problem, but a complex social problem as well. In this study, the prevalence of malnutrition found in an orthopaedic patient population differed with individual indices of malnutrition. These differences are explained by the fact that each test reflects the status of a different metabolic function or body compartment or both. Other studies have reported different prevalence rates of malnutrition using albumin and TLC indices. Koval *et al.*<sup>7</sup> who did a study on the effect of nutritional status on the outcome after hip fracture treatment, revealed a malnutrition rate of 55% and 18% using TLC and albumin indices respectively. Schneider *et al.*<sup>8</sup> reported a prevalence of malnutrition of 67.8% using the albumin index.

Malnutrition in general is widely reported in the literature as a predisposing entity towards development of peri-operative complications.<sup>9</sup> Sepsis in clean wounds is a reflection of surgical and nursing standards. Contamination during surgery is usually minimal and limited to the patient's own skin flora when aseptic techniques are observed.

However, exogenous infection of clean wounds can occur following contamination as a result of sloppy nursing on postoperative wound care. Such poor nursing care can be attributed to early discharge from hospital as it appeared in this study where those who developed wound infections had shorter postoperative hospital stay (mean 3.44 days) compared to their counterparts (mean 4.00 days). Discharged patients are instructed to attend nearby health facilities to have their wounds attended to while awaiting the date of their follow-up at clinics. Some of these health facilities face a shortage of nurses and have no reliable access to sterile dressing kits. As a result they fail to observe antiseptic methods during wound care. The overall prevalence of wound infection found in this study was 9.0%. This rate is beyond the acceptable limits of the expected rates of postoperative wound infection of clean surgical procedures, which is 1–5%.<sup>10</sup> Ideally the rate is supposed to be less than 2%.<sup>11</sup> However, this is possible only under strict surveillance programmes. The belated administration of prophylactic antibiotics only following surgery and the tendency of allowing operated patients to have their wounds dressed at dispensaries and health centres are likely to have contributed to the occurrence of such a high rate of infection. Factors like socio-economic status have an influence with regard to the quality of health services being offered. Countries with low socio-economic status are likely to face higher infection rates than countries with improved socio-economic status. This study was conducted in an environment of low socio-economic status where availability of human and material resources for health is a challenge. Reports from other countries show different rates of wound infection. In Mexico a lower rate of wound infection of 1.3% was reported in 1999.<sup>12</sup> In another study done in Nigeria in 1992, the rate of wound infection in clean surgical procedures was found to be 2%. Other studies, however, have reported higher rates of wound infection. In India for example, a rate of wound infection in clean surgery of 12% was reported in 1998.<sup>13</sup>

As it was found to be predictive to SSI in this study, low albumin has also been reported in other studies to be predictive of a number of postoperative outcomes. Koval *et al.*<sup>7</sup> reported abnormal albumin to be predictive of increased length of hospital stay postoperatively ( $P = 0.03$ ). Another study by Greene *et al.*<sup>14</sup> reported a seven times increased risk of developing wound complications following either total hip or total knee arthroplasty when the albumin level was  $< 3.5$  g/dl.

The increased risk to the development of wound infection in patients with TLC of  $< 1\ 500$  observed in this study closely correlates to findings in other studies.<sup>14</sup>

The ability of the co-existence of low levels of both albumin and TLC in predicting postoperative wound infection has been reported in the Koval *et al.* study.<sup>7</sup>

SSI is influenced by a variety of factors which include morbid obesity, prophylactic antibiotic use, operation time, and HIV status. Derangement of a single factor may not cause significant adverse effects to the surgical wound as it appeared in this study, where none of the obese developed wound infection postoperatively. Such findings are comparable to those obtained in research done at Jinnah Hospital Lahore, Pakistan.<sup>15</sup> There is no universal agreement on the role of duration of surgery to the occurrence of wound infection postoperatively. However, it has been reported that an operation lasting more than 2 hours carries a high risk of infection.<sup>16</sup> Infection rate roughly doubles with every hour.<sup>17</sup> All patients who were identified as HIV-positive in this study (8%) were asymptomatic. This prevalence is close to the national HIV prevalence (7%) according to the Tanzania HIV/Aids Indicator Survey (THIS) which was conducted in Tanzania mainland in the year 2003/04.<sup>18</sup> Contrary to basic science studies which have demonstrated impairment of defences to routine orthopaedic pathogens as well as to opportunistic organisms, clinical studies have shown that this impairment has not resulted in an increased incidence of postoperative infections in asymptomatic HIV-positive patients. Even for the symptomatic patient, current medical management appears adequate to reduce the risk of early postoperative infection. However, an HIV-positive patient with a prosthetic implant may be at increased risk for late haematogenous implant infection as host defences diminish.<sup>19</sup> It is therefore important to make sure that HIV-positive patients are regularly followed up and their CD 4 levels are being monitored.

Limitations of this study include failure to evaluate other factors that influence the occurrence of wound infection, such as surgical technique in relation to type of implant, soft tissue handling, maintenance of aseptic state and level of energy transfer.<sup>11</sup> The study identified increased risk of infection in a case where both albumin and TLC were low. But statistical analysis with the Chi-square method was not possible as the number was small. The recommended use of antibiotic prophylaxis is to start pre-operatively and only administer these for 24 hours. The regimen in this study was different and its effect on the occurrence of sepsis was not evaluated. Lack of significant association between HIV status and SSI found in this study should be taken with caution since levels of immunity in these individuals remained unknown.

In conclusion, patients at risk of SSI can be identified pre-operatively using relatively inexpensive laboratory tests of nutritional parameters. Preventive measures like nutritional support and prophylactic antibiotics can then be instituted. A parameter predictive of postoperative wound infections is hypoalbuminaemia. However, a larger study group with greater variance is necessary to be able to analyse both parameters statistically.

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