International Journal of Orthopaedics Sciences

ISSN: 2395-1958
IJOS 2019; 5(1): 158-163
© 2019 IJOS
www.orthopaper.com
Received: 26-11-2018
Accepted: 30-12-2018

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Correlation of fracture patterns with nutritional status in long bone fracture

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DOI: https://doi.org/10.22271/ortho.2019.v5.i1c.30

Abstract
Background: Nutrition is one of the important factors that influences bone health. Fractures are quite common and increasing in prevalence in younger ages which could be because of the poor nutrition leading to poor bone health. We have evaluated the correlation between the nutritional status and long bone fracture pattern's in patients not known or suspected to be Osteoporotic.
Methods: This study was conducted in 85 patients with long bone fracture presenting within 14 days of injury. Patients meeting the criteria for this study had their hematological and biochemical studies done on admission to Orthopaedic wards to document their nutritional status. Patients were evaluated on the basis of their age, gender, fracture pattern's, modes of injury, and laboratory investigations relevant for nutritional assessment.
Result: Out of total 85 cases in our study 92.94% (n=79) had low serum vitamin-D level, 62.35% (n=53) had low TLC's level, 9.41% (n=8) had deranged serum creatinine level and 44.70% (n=38) had suboptimal serum albumin level at the time of admission which reflects the poor bone health of even young age group patients. Trend toward more severe fracture pattern was seen among fracture under 18 to 40 year age group patients with deranged nutritional biochemical parameters. Significant p value ($p<0.05$) were obtained in patients with derranged Serum Creatinine, BUN and RBS level. Although apparently the data shows that frequency of comminuted, segmental and oblique fracture were higher where nutritional parameters are below normal or suboptimal but significant p value could not be obtained in the rest of the nutritional parameters since the number of patients in some fracture patterns were too low or nil to provide an adequate statistical comparison.
Conclusion: Our results on Orthopaedics trauma patients demonstrate that malnutrition is prevalent even in the younger age groups as evidenced by deranged parameters used to ascertain nutritional status. The general trend was of increased fracture severity patterns where Serum Albumin, Serum Calcium, Serum Phosphorus, Serum Creatinine, Blood Urea Nitrogen, Blood Sugar and Serum Vitamin-D were deranged, but a significant p value was obtained only in Serum Creatinine, BUN and RBS.

Keywords: nutrition, osteoporotic, bone health

Introduction
Proper nutrition is an essential parameter of skeletal health, affecting both the prevention and the treatment of bone diseases [1]. Studies even in the western population and in the developed countries have consistently shown that 30-40% of patients show evidence of poor nutrition on admission to hospital [2]. There is a 42% prevalence of elevated risk for malnutrition among adult patients with orthopaedic trauma [3]. Poor nutritional status has been identified as a causative factor in sustaining fractures [4]. Orthopaedic injuries can be said to be acute or chronic [5-8]; their generally accepted duration being: acute (0 to 4 days), sub-acute (5 to14 days), and post-acute (> 14 days) [6].
Nutrition screening identifies individuals who are malnourished or who are at risk for malnutrition, so that it can be ascertained if a more detailed assessment by medical, nutrition, and medication histories; along with physical examination, anthropometric measurements, and laboratory data is required or not [5].
Nutritional screening should be valid, simple, easy to use and sensitive enough so that it can be used widely and consistently even by non-specialists. A range of screening tools, anthropometric and non-anthropometric have been developed and validated by numerous studies [9].

Limitations of anthropometric screening and assessment include reliance on self-reported data, inaccurate measurement of anthropometric parameters in injured or elderly patients [10].

Among non-anthropometric, dietary history and relevant lab test like Serum Albumin, Serum Calcium, Serum Phosphorus, Haemoglobin, Total Lymphocyte Count (TLC), Blood Urea Nitrogen (BUN), Serum Creatinine are the appropriate tools needed for an accurate evaluation of a patient's preoperative nutritional status [11]. In Orthopaedics trauma patients evaluation of multiple serum biomarkers provide a greater specificity as well as sensitivity as diagnostic tools rather than relying on one biochemical marker as a nutritional assessment tool [12].

Jamie A. Nicholson, Adam S. Dowrick, Susan M. Liew in their study took suboptimal nutrition as a Serum Albumin level of <3.5 g/dl and a TLC of <1.50 cells/mm. They also found that male gender, old age, and presentation with trauma were risk factors for suboptimal nutritional parameters [13]. Studies revealed that due to the fracture and consecutive surgical operation, patients Albumin and Haemoglobin levels dropped below normal ranges within 2 to 3 weeks therefore these value become no longer relevant for evaluating the nutritional status after 2 week of injury [14].

These results confirm the usefulness of nutritional status assessment as a predictor of malnutrition. Thus this method not only becomes a tool for diagnosing a particular health state but also for having an idea of the prognosis. In this article, we tried to correlate the nutritional status with fracture patterns in non-osteoporotic adult patients with long bone fracture.

Methods

The observational study (Cross sectional) was conducted over a period of 12 months on 85 patients (18 - 40 year age) with long bone fracture those presenting within 14 days of injury. The study was conducted after taking clearance from ethical committee in the Department of Orthopaedics at Himalayan institute of Medical Sciences, Swami Ram Nagar, Dehradun.

Data collection

All patients (18 - 40 year age) with long bone fracture presenting within 14 days of injury were included. Patients outside age criteria, those presenting after 14 days of injury, those having known chronic debilitating diseases affecting nutritional status, on medications causing osteoporosis, history of blood transfusion after injury, pathological fractures, congenital deformity at fracture site, evidence of sepsis elsewhere in the body at the time of admission, history of factors causing or making susceptible to Osteoporosis, patient in haemorrhagic/ hypovolemic shock on presentation were excluded from the study.

The Study Tool used in this study were case reporting form to generate data, X-Ray findings to note the type of fractures, hematological parameters that is, Haemoglobin, Total Lymphocytes Count, DLC, biochemical parameters that is, Serum Albumin, Serum Calcium, Serum Phosphorus, Serum Creatinine, Blood Urea Nitrogen, Blood Sugar and Serum Vitamin-D. Normal levels taken in our study were according to Himalayan hospital haematological and biochemical database. All patients meeting the criteria for this study, admitted with acute and sub-acute long bone fractures were subjected to detailed history, thorough clinical examination and laboratory investigations. Results were evaluated on the basis of their age, duration of injury, different modes of injury, fracture patterns, fracture severity (on the basis of etiology of fracture severe fractures included comminuted, segmental and spiral fracture patterns and non-severe fractures included oblique and transverse fracture patterns) and laboratory investigations.

Data analysis

Statistical testing was conducted with the statistical package for the social science system version SPSS 22.0. Qualitative Data i.e. gender, complications etc. were expressed in terms of frequency and percentage. Quantitative Data i.e. CBC, etc. were expressed in terms of mean ± standard deviation. Nominal categorical data between the groups were compared using Chi-squared test or Fisher's exact test as appropriate. $p < 0.05$ was considered statistically significant.

Results

There were 11.76% (n=10) fracture cases in the 18-20 years age group, 54.12% (n=46) in the 21-30 years age group and 34.12% (n=29) in the 31-40 years age group. The mean age of fracture patients were 28.37 ± 6.25. Of 85 fracture cases, 83.53% (n=71) were males and 16.47% (n=14) were females. Male to female ratio were 5:1.

There were 91.76% (n=78) patients with high velocity trauma, 8.24% (n=7) patients with low velocity trauma and no patients with trivial trauma. Out of 78 patients with high velocity trauma 85.89% (n=67) patient were male and 14.10% (n=11) patient were female. There were 91.76% (n=78) acute fracture patients and 8.24% (n=7) were sub-acute fracture patients.

Out of 85 patients 76.47% (n=65) were closed type fracture and 23.53% (n=20) were open type fracture. Out of 65 closed fracture patients 89.23% (n=58) were due to high velocity trauma and 10.76% (n=7) were due to low velocity trauma. However all patients with open type of fracture were due to high velocity trauma.

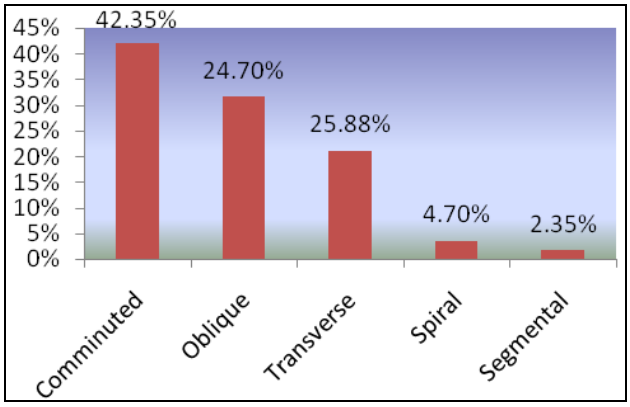

Fig 1: Showing fracture pattern wise distribution of study patients

Table 1: Baseline haematological and biochemical parameters of 85 trauma patients

Nutritional Parameters	Mean ± SD	Median	Min – Max
Haemoglobin	12.79 ± 2.08	13.15	6.86 - 1.5.84
TLC	2.21 ±1.21	1.84	0.34-4.05
S. Albumin	3.43 ± 0.68	3.52	1.05 - 4.08
S. Phosphorus	5.02 ± 2.59	4	1 – 9.6
S. Calcium	24.25 ± 26.63	9	7.1 – 117
Vitamin-D	12.78 ± 2.08	13.18	20.2 - 85.5
Random blood sugar	73.91 ± 54.07	98	62 – 186
S. Creatinine	4.34 ± 5.66	0.80	0.50 - 1.20
BUN	10.81 ± 3.82	10.20	3.4 - 20.8

Table 2: Showing association of Serum Albumin level with fracture patterns in our study patients (n=85)

S. Alb (g/dL)	Fracture pattern					P Value
	Comminuted	Oblique	Segmental	Spiral	Transverse	
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	
Suboptimal	18 (47.36%)	11 (28.94%)	1 (2.63%)	1 (2.63%)	7 (18.42%)	0.551
Normal (3.5 -5.5g/dL)	18 (38.29%)	10 (21.27%)	1 (2.12%)	3 (6.38%)	15 (31.91%)	
Total	36	21	2	4	22	

*Chi square test

Table 3: Showing association of Vitamin-D level to fracture patterns in our study patients (n=85)

Vitamin-D (nmol/L)	Fracture pattern					P Value
	Comminuted	Oblique	Segmental	Spiral	Transverse	
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	
Deficient (<25nmol/L)	6 (50%)	3 (25%)	1 (8.33%)	1 (8.33%)	1 (8.33%)	0.557
Insufficient (25 – 74 nmol/L)	27 (40.29%)	17 (25.37%)	1 (1.49%)	3 (4.47%)	19 (28.35%)	
Normal (75-20 nmol/L)	3 (50.0%)	1 (16.66%)	0 (0.0%)	0 (0.0%)	2 (33.33%)	
Total	36	21	2	4	22	

*Chi square test

Table 4: Showing association of TLC level to fracture patterns in our study patients (n=85)

TLC (10^9/L)	Fracture pattern					P Value
	Comminuted	Oblique	Segmental	Spiral	Transverse	
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	
Deranged	19 (35.84%)	15 (28.30%)	2 (3.77%)	3 (5.66%)	14 (26.41%)	0.457
Normal (1.5-4 10^9/L)	17 (53.12%)	6 (18.75%)	0 (0%)	1 (3.12%)	8 (25%)	
Total	36	21	2	4	22	

*Chi square test

Table 5: Showing association of Haemoglobin level to fracture patterns in our study patients (n=85)

Hb levels in female (g/dL)	Fracture pattern					P Value
	Comminuted	Oblique	Segmental	Spiral	Transverse	
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	
Anemic	4 (36.36%)	1 (9.09%)	0 (0%)	3 (27.27%)	3 (27.27%)	0.374
Normal (>12 g/dL)	2 (66.66%)	1(33.33%)	0 (0%)	0 (0%)	0 (0%)	
Total	6	2	0	3	3	

*Chi square test

Hb levels in male (g/dL)	Fracture pattern					P Value
	Comminuted	Oblique	Segmental	Spiral	Transverse	
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	
Anemic	14 (56%)	5 (20%)	1 (4%)	0(0%)	5 (20%)	0.436
Normal (>13g/dL)	16 (34.78%)	14 (30.43%)	1 (2.17%)	1 (2.17%)	14 (30.43%)	
Total	30	19	2	1	19	

*Chi square test

Table 6: Showing association of Serum Creatinine level to fracture patterns in our study patients (n=85)

S. Creatinine (mg/dL)	Fracture pattern					P Value
	Comminuted	Oblique	Segmental	Spiral	Transverse	
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	
Deranged	1 (12.5%)	3 (37.5%)	0 (0%)	2 (25%)	2 (25%)	0.034 significant
Normal (0.6-1.2 mg/dL)	35 (45.45%)	18 (23.27%)	2 (2.59%)	2 (2.59%)	20 (25.97%)	
Total	36	21	2	4	22	

*Chi square test

Table 7: Showing association of BUN to fracture patterns in our study patients (n=85)

BUN (mg/dL)	Fracture pattern					P Value
	Comminuted	Oblique	Segmental	Spiral	Transverse	
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	
Deranged	2 (11.11%)	6 (44.44%)	0 (0%)	0 (0%)	6 (44.44%)	0.077
Normal (7-20 mg/dL)	34 (47.91%)	15 (29.16%)	2 (2.08%)	4 (4.16%)	16 (16.66%)	
Total	36	21	2	4	22	

*Chi square test

Table 8: Showing association of Serum Calcium to fracture patterns in our study patients (n=85)

S. Calcium (mg/dL)	Fracture pattern					P Value
	Comminuted	Oblique	Segmental	Spiral	Transverse	
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	
Deranged	17 (54.83%)	5 (16.12%)	0 (0%)	3 (9.67%)	6 (19.35%)	0.100
Normal (8.5-10.5 mg/dL)	19 (35.18%)	16 (29.62%)	2 (3.7%)	1 (1.85%)	16 (29.62%)	
Total	36	21	2	4	22	

*Chi square test

Table 9: Showing association of Serum Phosphorus to fracture patterns in our study patients (n=85)

S. Phosphorus (mg/dL)	Fracture pattern					P Value
	Comminuted	Oblique	Segmental	Spiral	Transverse	
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	
Deranged	12 (50%)	6 (25%)	0 (0%)	1 (4.16%)	5 (20.83%)	0.808
Normal (2.5-4.5mg/dL)	24 (39.34%)	15 (24.59%)	2 (3.27%)	3 (4.91%)	17 (27.86%)	
Total	36	21	2	4	22	

*Chi square test

Table 10: Showing association of Random Blood Sugar level to fracture patterns in our study patients (n=85)

RBS (mg/dL)	Fracture pattern					P Value
	Comminuted	Oblique	Segmental	Spiral	Transverse	
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	
Deranged	7 (70%)	1 (10%)	1 (10%)	0 (0%)	1 (10%)	0.112
Normal (70-140 mg/dL)	29 (38.66%)	20 (26.66%)	1 (1.33%)	4 (5.33%)	21 (28%)	
Total	36	21	2	4	22	

*Chi square test

Discussion

In an earlier study on nutritional status of medical students done in our institute it was found that these young individuals from well to do families were found to have a significant incidence of osteopenia. Based on this fact we wanted to study if osteopenia and osteoporosis had any bearing on fracture patterns in individuals not having any known factor resulting in osteoporosis or osteopenia. The data has been gathered and analyzed from this perspective [15].

In our study we found that only 8.24% (n=7) of our patient had sustained fractures due to low velocity trauma and the female patients constituted only 16.47% (n=14) of the cases whereas male patients were 83.53% (n=71). Divesh Gulati *et al*. conducted a study on proximal femoral fractures in 20-40 year of age group patients and reported that only 6.6% of their patients sustained the fracture due to trivial trauma and 20% of their patients were female. They rationalized that this gender predilection could be due to higher mobility of male individuals and their susceptibility to road traffic accident especially among young adults, since in India mostly women are often confined to households [16].

Out of our 85 fracture patients 42.35% (n=36) patients had comminuted type of fracture, 24.70% (n=21) had oblique type of fracture, 25.88% (n=22) patients had transverse type of fracture, 4.70% (n=4) patients had spiral type of fracture and 2.35% (n=2) patient had segmental type of fracture pattern (Fig-6). We could not locate any study that showed incidence on the basis of similar fracture patterns.

Jamie A. Nicholson *et al*. in their study found that Serum Albumin levels were low in 32% of their patients at the time of admission and their mean values were 3.9 (range, 2.3–4.9) g/dl [17]. Sabir Ali *et al*. in their study of diphyseal fracture of tibia in age group 18-45 year found that 21 (32.30%) patients out of 65 patient had suboptimal level of Serum Albumin whereas 44 (67.69%) of patients had normal level [18]. In comparison we found that 38 (44.70%) patient had suboptimal level of Serum Albumin and 47 (55.29%) patients had normal level of Serum Albumin indicating a poor nutritional status in a significant number of our patients at the time of admission. But no statistically significant correlation between Serum Albumin level and individual fracture patterns (p=0.551) and on the basis of severity of fracture pattern (p=0.752) could be established.

Arya V. *et al* in their study among the hospital staff in north India demonstrated that 66.3% cases had insufficient Serum Vitamin-D levels and are at high risk of fractures [19]. Tangpricha V. in their study among age group of 17-35 years found high (56%) prevalence of Vitamin-D insufficiency and are prone to fractures [20]. Similarly Qing-Bo Lv. *et al*. in their study found that risk of hip fracture was high when the Serum Vitamin-D level was less than 60 nmol/L [21]. 4 (7.01%) patients had fracture due to low velocity trauma and all 4 patients had low level of Vitamin-D. Our study was in accordance with these studies and we found that 78.82% (n=67) of our young adults had insufficient Vitamin-D level whereas 14.11% (n=12) were Vitamin-D deficient.

In our study we found that majority of our patients i.e. 79 (92.94%) out of 85 had suboptimal Vitamin-D levels. Amongst those with suboptimal Vitamin-D levels majority of the patients had severe fracture patterns (comminuted, oblique, segmental) suggesting that suboptimal Vitamin-D levels are associated with more severe fracture patterns, which could be due to a poor bone health in patients with suboptimal Vitamin-D levels.

91.66% (n=33) out of 36 patients with comminuted fracture patterns, 95.23% (n=20) out of 21 oblique fracture pattern patients, 100% (n=2) of segmental fracture pattern patients, 100% (n=4) spiral fracture pattern patients and 90.9% (n=20) out of 22 transverse fracture patterns patients had suboptimal Vitamin-D level. But no statistically significant correlation between Vitamin-D levels and individual fracture patterns (p=0.557) and on the basis of severity of fracture patterns (p=0.69) could be established.

Basu *et al*. in their study found that 87.87% of their patients had suboptimal TLC's level and indicating that abnormal pre-op Lymphocyte Counts at the time of admission shows

malnutrition [22]. Similarly Jamie A. Nicholson *et al*. in their study found that 56% of their patients had suboptimal TLC's level and their mean value were 1.43 (range, 0.25–4.87) cells/mm [17]. Our study were in accordance with I. Basu *et al*. and Jamie A Nicholson *et al*. study and we found that 62.35% of our patient had suboptimal TLC level at the time of admission and median of patient's TLC were 1.84 (range, 0.34-4.05) and mean were 2.21±1.21 showing poor nutritional status of our patients. No statistically significant correlation between TLC level and individual fracture patterns (p=0.45) and on the basis of severity of fracture patterns (p=0.44) could be established.

In our study 11 female and 25 male patients had low Haemoglobin level at the time of admission, out of which majority of them is showing severe type of fracture patterns. But no statistically significant correlation between Haemoglobin level and individual fracture patterns (p=0.37 of female and p=0.43 for male) and on the basis of severity of fracture patterns (p=0.56 of female and p=0.55 for male) could be established.

In our study we found 16.47% (n=14) patients with deranged BUN and 9.41% (n=8) patients with deranged levels of Serum Creatinine. But no statistically significant correlation between BUN and individual fracture patterns (p=0.07) could be established, however statistically significant correlation between deranged BUN and severe fracture patterns (p=0.009) is seen. Statistically significant correlation between Serum Creatinine and individual fracture patterns (p=0.03) is seen but no statistically significant correlation between Serum Creatinine and severe fracture patterns (p=0.73) is seen.

In our study only 36.47% (n=31) of patients had low Serum Calcium level at the time of admission and 54.83% (n=17) of them had comminuted type of fracture patterns**.** Elevated Serum Phosphorus level has been related with the increase in risk of fracture. Campos-Obando *et al*. reported that increased Serum Phosphorus levels even within normal range is harmful for the health of bone. They found that potential threshold of Serum Phosphorus level were 3.3 mg/dL in male and 3.7 mg/dL in female above which fracture risk was increased [23]. In our study the mean level of normal Serum Phosphorus in male patients were 3.49 whereas in female patients were 3.49, thus showing increase fracture risk in male patients in our study compared with female patients. But no statistically significant correlation between Serum Calcium and individual fracture patterns (p=0.10) and severity of fracture pattern (p=0.05) as well as Serum Phosphorus and individual fracture patterns (p=0.80) and severity of fracture pattern (p=0.75) could be established.

H. Holmberg *et al*. in their study indirectly suggested a positive effect on bone from hyperglycemia [24]. Similarly Rotterdam study showed that impaired glucose tolerance patient had low fracture risk [25]. Our finding were in accordance with the both studies and we found that only 10 patients in our study were hyperglycemic during admission and all of them sustained fracture due to high velocity and all fracture patterns were severe. We were able to find statistical significant correlation between Random Blood Sugar and severe fracture patterns (p=0.04) however no statistical significant correlation between Random Blood Sugar and individual fracture patterns (p=0.11) could be established.

Our results demonstrate that malnutrition in Orthopaedic trauma patients is significantly prevalent even in the young non-osteoporotic population; since nearly all of our patients have one or more deranged lab parameters that are used to ascertain nutritional status. We have demonstrated statistically significant correlation between Serum Creatinine and individual fracture patterns and between BUN and RBS in severe fracture patterns. Although our data shows a very evident trend toward severe fracture patterns in patients with deranged biochemical values especially in Vitamin-D level but significant p value could not be obtained since the number of patients in some categories were too low or nil to provide an adequate statistical comparison.

Conclusion

Nutrition holds a dominant role in maintaining bone health. Poor nutrition may not be evident, unless looked for, though the patient may be malnourished. Consequently patient may not receive any nutritional treatment and therefore the treatment outcome might not be satisfactory. The application of nutritional assessment tools will recognize patients who are at risk of malnourishment and who need more formal assessment and treatment accordingly.

We conclude that young adults have greater status of malnutrition than is evident, which might be the cause for the apparent severity of fracture patterns seen in the younger age group we have studied. Hence medical personnel involved in patient management should also assess the nutritional status of their patients for a better outcome. An enhancement of public awareness and education regarding importance of nutrition and bone health even in the younger age group should be done.

The present study had some limitations that should be considered which are low volume of cases in our study and non feasibility to take anthropometric data of our trauma patients to utilize all defined parameters for nutritional assessment.

Acknowledgement

Author would like to thanks all the nursing staff for their cooperations.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the institutional ethics committee

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