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Serum Lipid Profile Changes And Fat Embolism Risk In Patients Who Undergo Reamed Intramedullary Nailing For Acute Long Bone Fractures

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Abstract
Background: *Fat embolism syndrome (FES) is a known complication of long bone fractures and intramedullary nailing. The relationship between serum lipid profile changes and fat embolism remains an area of interest. This study evaluates the effect of reamed intramedullary nailing on serum lipid profile changes and its association with fat embolism syndrome.*
Methods: *A prospective study was conducted on 57 patients with acute long bone fractures undergoing reamed intramedullary nailing. Serum lipid profile concentrations were measured preoperatively, intraoperatively, and 72 hours postoperatively from both femoral and cephalic veins. Samples were analyzed using spectrophotometry. Statistical analysis was performed using SPSS version 22, with comparisons made using the Student's t-test and a significance level set at $p < 0.05$. Correlations between reamer and nail sizes and serum lipid concentrations were also analyzed.*
Results: *The mean serum lipid concentrations showed a marginal intraoperative rise in the femoral vein, followed by a decline within 72 hours postoperatively. In the cephalic vein, serum lipids continued to rise beyond 72 hours, except for HDL, which decreased postoperatively. There was a statistically significant difference ($p < 0.05$) between preoperative and postoperative serum lipid levels for both femoral and cephalic veins. However, there was no significant difference between the lipid concentrations in the femoral and cephalic veins. The size of the reamer and nail used did not significantly influence serum lipid levels. One patient with bilateral femoral fractures developed subclinical FES intraoperatively, with transient desaturation and hemodynamic instability, which resolved with supportive management.*
Conclusion: *Reamed intramedullary nailing results in transient elevations of serum lipids, but these changes do not exceed normal reference ranges and are not associated with clinically significant fat embolism syndrome. The procedure remains safe for hemodynamically stable patients. However, patients with multiple long bone fractures may require closer monitoring due to the potential cumulative effect of fat embolism. Further intraoperative studies are needed to assess fat macroglobules in circulation.*
Keywords: *Fat embolism syndrome, serum lipid profile, intramedullary nailing, reaming, long bone fractures*

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I. Introduction

Acute long bone fractures predominantly arise from high-impact trauma in young adults and low-energy injuries in the elderly population [1–5]. Motor vehicle accidents, sporting activities, falls, and assaults are among the most frequently reported mechanisms of lower limb long bone fractures [1, 4, 6, 7]. The tibia, followed by the femur, represents the most commonly fractured long bones in the human body [4, 6, 7]. In some cases, multiple long bones of the lower limb may sustain fractures concurrently, further complicating management and clinical outcomes [5–7].

Meling et al. reported an incidence of 417 per 100,000 injuries per year in the United States [8], while Ikem et al. documented a slightly higher incidence of 456 per 100,000 injuries per year in a study conducted in southwestern Nigeria [6]. This increasing incidence is largely attributed to the rising number of road users, industrialization, participation in sports, communal conflicts, and acts of terrorism [6, 7].

Within the bone marrow, stromal cells and adipocytes play a crucial role in hematopoiesis and lipid metabolism. Fracture or surgical intervention, such as intramedullary nailing, can disrupt these anatomical structures, leading to marrow displacement. Traumatic forces that result in long bone fractures not only disrupt bone integrity but also cause significant injury to adjacent structures, including the periosteum, muscles, and surrounding soft tissues. This mechanical disruption facilitates the intravasation of bone marrow contents, which are rich in lipids. The systemic release of these fat-laden components has been hypothesized to contribute to alterations in serum lipid profiles, potentially influencing both metabolic and inflammatory responses following long bone fractures and their surgical management [9].

Reamed intramedullary nailing remains the gold standard for the fixation of diaphyseal long bone fractures, performed using either an open or closed technique, with or without the aid of an image intensifier [2, 4]. Serial reaming of the intramedullary canal facilitates the insertion of a larger diameter nail, thereby enhancing the mechanical stability of the fractured bone [4]. Despite the superior biomechanical advantages of reamed intramedullary nailing over other fixation methods, the procedure is associated with endosteal vessel disruption and marrow content displacement, leading to the intravasation of medullary components into systemic circulation, among other potential complications [9].

Reaming and nailing significantly increase intramedullary canal pressure, from a baseline of approximately 30 mmHg to as high as 830 mmHg, which in turn facilitates the systemic release of bone marrow contents [10–12]. The extent of lipid intravasation has been shown to correlate directly with the degree of pressure elevation following reaming and nailing [9, 10, 13]. Notably, reamed femoral nailing results in greater lipid intravasation compared to reamed tibial nailing, likely due to differences in canal size and marrow composition [14]. Elevated serum lipid concentrations have been detected in 67% of trauma patients, with this prevalence rising to 95% in those who undergo reamed intramedullary nailing [9, 13, 15].

A strong positive correlation has been observed between increased serum lipid concentrations and the size of fat globules detected in the circulation of patients who have undergone reamed intramedullary fixation for long bone fractures [16]. The higher the serum lipid concentration, the greater the risk of developing fat embolism syndrome (FES) [17]. FES often results from the systemic embolization of fat droplets, typically from bone marrow, into the circulation, leading to a constellation of multi-organ symptoms [5]. It most commonly occurs after long bone fractures or orthopedic procedures and manifests through pulmonary, neurological, and dermatological signs. Key systemic features include hypoxemia, respiratory distress, altered mental status, petechial rash, tachycardia, fever, and thrombocytopenia, typically appearing within 24–72 hours after the inciting event [14]. Histological evidence of fat emboli has been identified in vital organs, including the lungs, heart, kidneys, and brain, further underscoring the systemic implications of lipid intravasation [11, 18]. Although FES is a rare occurrence, it is often fatal when it does develop [13, 18]. However, patients who present with subclinical features generally experience full recovery without long-term complications [19].

Efforts to mitigate medullary hypertension and reduce serum lipid intravasation during reamed intramedullary nailing have included various techniques such as unreamed nailing, high-compression versus low-compression reaming, and modifications in reamer head design, including end-cutting and side-cutting configurations [9]. Additional strategies such as reamed irrigator aspiration (RIA) and venting during nailing have also been explored to minimize systemic lipid embolization [20]. However, in our local setting, many of these techniques are not yet widely implemented. Despite this, the incidence of FES remains relatively low, as demonstrated by Edomwonyi et al., who reported an incidence of 11.11% in southwestern Nigeria, which is lower than the 19% reported by Bulger et al. in the United States [21, 22].

Experimental studies in both humans and animal models suggest that lipid intravasation following reaming is limited due to the decompressive effect of the fracture itself. The disruption of the medullary cavity from the fracture reduces intramedullary pressure, thereby minimizing fat release into systemic circulation during reamed intramedullary nailing [23, 24]. This phenomenon may contribute to the relatively low incidence of clinical FES observed following immediate intramedullary nailing of long bone fractures [23, 25].

This study aims to evaluate the changes in serum lipid profiles following reamed intramedullary nailing in acute lower limb long bone fractures. It specifically compares preoperative serum lipid levels with intraoperative and postoperative levels to assess the metabolic alterations induced by the surgical procedure.

Intramedullary nailing remains the gold standard for the fixation of long bone fractures, requiring serial reaming to facilitate the insertion of an appropriately sized nail. This process displaces bone marrow contents into the systemic circulation, potentially leading to deleterious physiological effects. However, the impact of reaming on serum lipid profiles in patients with long bone fractures has not been fully explored, particularly in our local population. Addressing this gap in knowledge is essential to improving patient outcomes and optimizing surgical techniques in our setting.

This study aimed to evaluate perioperative changes in serum lipid profiles among patients with acute lower limb long bone fractures treated with reamed intramedullary nailing. Specifically, it assessed lipid levels at three key time points—within 72 hours of injury, immediately after reaming and nailing, and 72 h postoperatively, to characterize dynamic metabolic responses to fracture and surgical intervention.

Additionally, the study compared lipid concentrations from femoral and cephalic venous samples to determine site-specific variations in lipid mobilization during and after reaming. It also examined associations between lipid alterations and surgical parameters, including reamer and nail sizes, to explore whether the extent of intramedullary instrumentation influences systemic lipid changes. Through these objectives, the study sought to elucidate the metabolic impact of reamed intramedullary nailing and its potential relationship with fat embolism risk and postoperative recovery.

II. Methods

This hospital-based prospective study aimed to assess serum lipid profile changes following reamed intramedullary nailing of acute long bone fractures in the lower limbs. The study was conducted in the Department of Orthopaedic Surgery and Traumatology at Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Osun State, Nigeria, which has a 650-bed capacity. The study received approval from the Ethics and Research Committee of Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife. Permission and support were obtained from the managing consultants in the orthopaedic department, as well as from the Head of Department. Written informed consent was acquired from all patients who met the inclusion criteria.

Study Population, inclusion, and exclusion criteria

The study population consisted of consenting patients who met the eligibility criteria at the Accident and Emergency Unit of Obafemi Awolowo University Teaching Hospital, Ile Ife, Osun State. Participants were recruited based on predefined inclusion and exclusion criteria to ensure the selection of appropriate candidates for the study.

Eligible participants included all consenting patients with acute long bone fractures of the lower limb who required open reduction and internal fixation with reamed intramedullary nailing. Only patients admitted within 72 h of injury were considered, regardless of whether they presented with single or multiple fractures. Both open and closed fractures of the lower limb long bones were included in the study to provide a comprehensive analysis of lipid profile changes across different fracture types.

Patients were excluded from the study if they had sustained multiple injuries involving the head, chest, or abdomen, as these could introduce confounding systemic effects. Additionally, individuals who exhibited clinical features suggestive of FES at presentation were not included, as the study aimed to assess lipid changes in the absence of pre-existing embolic complications. Patients with a known history of hyperlipidemia or those currently receiving treatment for the condition were also excluded to prevent pre-existing lipid abnormalities from influencing the study outcomes.

Pregnant women with long bone fractures were not included in the study due to the physiological changes associated with pregnancy, which could alter lipid metabolism. Similarly, patients with pathological long bone fractures were excluded, as these fractures are often associated with underlying metabolic or malignant conditions that could independently affect lipid levels. Patients who presented with long bone fractures beyond 72 h post-injury or those with established non-union were also excluded to maintain a uniform study population focused on acute fractures. Lastly, skeletally immature patients were not included, as variations in bone metabolism and lipid profiles in growing individuals could differ significantly from the adult population under investigation.

Sample Size

The sample size was calculated using the Leslie-Kish formula for a single proportion, accepting a 95% confidence interval level, a statistical significance of 0.05, and a power of 95%. The formula used was:

$$N = Z2pq/d2$$

With an estimated 10% attrition rate, a total of 57 participants were to be enrolled for this study.

Patients and Sample Collection

Patients who presented at the Accident and Emergency unit and satisfied the inclusion criteria were recruited into the study, and informed consent was obtained.

Initial resuscitation of the patients was carried out using the Advanced Trauma Life Support (ATLS) protocol to address all life-threatening injuries. The affected limb(s) were temporarily splinted with an external splint. Afterward, a complete patient evaluation was conducted, which included the patients' bio-data, relevant history and Clinical examination, including vital signs (pulse rate, blood pressure, respiratory rate, temperature), which were recorded in a structured information sheet.

The affected limb(s) were also examined. Pre-operative investigations included plain radiography of the fractured limb(s) and serum lipid profiles. All patients were fasted and placed on intravenous fluid therapy consisting of dextrose water alternating with normal saline before surgery. Blood samples for lipid profile were taken from the femoral vein, and another sample was taken from the cephalic vein under sterile conditions within 12–72 h of injury, both of which were placed into ethylenediamine tetraacetic acid (EDTA) bottles.

Surgery was performed in the operating theatre. At induction of anesthesia, prophylactic antibiotics were administered. Routine intra-operative skin preparation and draping were carried out to isolate the operation site. Standard incisions were made to access the fractured bone, which was reamed serially with increasing sizes of reamers. The largest size of reamer and nail used were recorded. The fractured bone(s) were stabilized with a locked intramedullary Surgical Implant Generation Network (SIGN) nail according to the SIGN nail manual. Immediately after stabilization of the fractured bone, blood samples were taken for serum lipid profile from the same sites as the pre-operative samples. Additional samples were taken from the peripheral cephalic vein, and both samples were placed into separate EDTA bottles. The femoral and cephalic vein samples were drawn from the side of the fractured limb when feasible. In cases where this was not possible, sampling was done from the contralateral limb. The samples were properly mixed in the bottles and labelled. Oxygen saturation (SpO_2), temperature, respiratory rate, and blood pressure were recorded before and immediately after reaming and nailing. The wounds were closed in layers, and the skin was closed with either sutures or staples.

Another sample was taken 72 h post-operatively at the same intra-operative sampling site on the wards. Both samples were placed into ethylenediamine tetraacetic acid (EDTA) bottles separately, mixed properly, and labeled. All collected samples were transported to the chemical pathology laboratory, where serum was harvested and analyzed using the spectrophotometry method. The tests were standardized using control samples that were obtained from the manufacturers of the reagents and analytical kits. The values obtained from the controls were also within the range specified by the manufacturer. The kits used included the following: Cholesterol kits (Agappe Inc. Knonauerstrasse 54-6330 Cham, Switzerland GmbH) Kits for HDL assay (Agape Inc. Knonauerstrasse 54-6330 Cham, Switzerland GmbH), and triglyceride analysis kits (Agappe Inc. Knonauerstrasse 54-6330 Cham, Switzerland GmbH). The levels of LDL was assessed using the friedewald equation.

$$LDL - C = Total\ Cholesterol - HDL - C - (Triglycerides\ /\ 5)$$

Results were entered into a proforma. The patients were closely monitored throughout the preoperative, intraoperative, and postoperative periods. An experienced chemical pathologist measured the serum lipid profile for all patients included in the study.

Statistical analysis

Data were analysed using the Statistical Package for Social Sciences (SPSS) version 22 (IBM Corp., Armonk, NY, USA) and Microsoft Excel. The mean values for femoral and cephalic vein serum lipid profiles were recorded. Preoperative serum lipid profile values were compared with intra-operative and postoperative values using a Student's t-test. Statistical correlations between the various sizes of the reamer and nail used were computed against the serum lipid profile. A frequency table and graphs were employed for data summary and presentation, with a p-value of <0.05 considered statistically significant.

III. Results

A total of 57 patients were analysed to evaluate changes in serum lipid profiles following reamed intramedullary nailing for acute lower limb long bone fractures. All recruited patients met the inclusion criteria. The mean age of participants was 45 ± 10.25 years, with the majority (56.1%) within the 20–44-year age group. Males constituted 57.9% of the cohort (male-to-female ratio 1.4:1).

Tibial fractures were the most common (64.9%), followed by femoral fractures (22.8%), as shown in Table 5.1. Tibial fractures occurred more frequently in males. Road traffic accidents were the leading mechanism of injury, accounting for 84.2% of cases, of which vehicular–bike collisions (29.8%) and vehicular–pedestrian incidents (22.8%) were predominant. Falls, assaults, and sports injuries were less frequent causes.

Open fractures were classified according to the Gustilo–Anderson system, with type IIIa being the most frequent (68%). For closed fractures, Winquist type IV predominated (50%). The most common fracture configuration was comminuted (25%), followed by transverse (23%) and oblique (18%) patterns.

Changes in Serum Lipid Profiles

Serum lipid concentrations (HDL, triglycerides [TG], LDL, and total cholesterol [TC]) were assessed at three critical time points—preoperatively (within 72 h of injury), intraoperatively (immediately after reaming and nailing), and 72 h postoperatively—to capture dynamic alterations in lipid metabolism associated with the surgical procedure.

Femoral vein lipid profiles

There was a consistent intraoperative increase in all lipid fractions compared with preoperative values, followed by a decline 72 hours postoperatively (Table 5.1, Figure 5.9). HDL rose from a preoperative mean of 1.53 ± 0.43 mmol/L to 1.72 ± 0.66 mmol/L intraoperatively, before decreasing to 1.59 ± 0.60 mmol/L postoperatively. Similar transient intraoperative elevations were observed in TG, LDL, and TC levels. Statistical comparison across the three time points revealed significant differences ($p < 0.05$ for all parameters).

Cephalic vein lipid profiles

A different trend was observed in the cephalic vein samples (Table 5.2, Figure 5.10). All lipid parameters showed intraoperative elevation, but unlike the femoral samples, TG, LDL, and TC continued to increase postoperatively, while HDL declined after surgery. Mean HDL decreased from 1.73 ± 0.51 mmol/L intraoperatively to 1.64 ± 0.52 mmol/L postoperatively. The observed differences between the three time points were statistically significant for all parameters ($p < 0.05$).

Comparison between femoral and cephalic veins

The intraoperative lipid rise was more pronounced in femoral vein samples, whereas the cephalic vein showed a more sustained postoperative elevation, suggesting site-dependent variation in lipid mobilization and clearance following reamed nailing. These findings collectively demonstrate that the metabolic response to reaming differs between central and peripheral venous systems.

Relationship Between Serum Lipids and Instrumentation Size

To explore whether the magnitude of reaming influenced lipid alterations, serum lipid changes were correlated with the largest reamer and nail sizes used intraoperatively. Among the cohort, 11 patients underwent reaming up to 10 mm (nail size 8 mm), 32 patients up to 11 mm (nail size 9 mm), and 14 patients up to 12 mm (nail size 10 mm). Statistical analysis showed no significant correlation between lipid level changes and either reamer or nail size ($p > 0.05$; Table 5.6). This suggests that within the studied range, instrumentation size did not significantly impact systemic lipid response.

Intraoperative and Postoperative Clinical Observations

During intraoperative serum processing, a single case of visible fat macroglobules was noted in a patient with bilateral closed femoral fractures. The macroglobule measured approximately 15 × 10 × 8 mm (Figure 5.11). Spectrophotometric analysis revealed reduced HDL concentration (0.64 mmol/L) relative to normal ranges, while TG (2.22 mmol/L), LDL (3.40 mmol/L), and TC (4.77 mmol/L) remained within reference limits (Table 1).

One patient developed transient subclinical features suggestive of fat embolism syndrome (FES) immediately following reaming and nailing. This was characterized by a brief drop in oxygen saturation to 68%, tachypnea (35 breaths per minute), tachycardia (102 beats per minute), and hypotension (80/50 mmHg). The episode resolved within 30 min with supportive care, and no further deterioration was observed postoperatively..

IV. Discussion

All the 57 patients who were recruited for the study were clinically stable, as indicated by their vital signs on admission. Most of the patients were in their productive age group, with a mean ± SD age of 45 ± 10.2 years. The highest frequency of acute long bone fractures occurred in the 20 to 44 years age group, accounting for 32 (56.1%) patients. Males had the highest occurrence of acute long bone fractures, as they are more likely to engage in traveling and sporting activities compared to females. This is consistent with studies conducted both in Nigeria and internationally [1, 4, 6].

Regarding the mechanism of injury, road traffic crashes accounted for the highest cumulative frequency, with 48 patients (84.2%), of which vehicle-bike collisions were the most common. This could be attributed to increased vehicular usage, poor driving habits, speeding, bad roads, and inadequately trained drivers. Similar findings were noted by Yinusa W et al. in 2010 [7]. In this study, road traffic crashes were high-energy injuries that resulted in complex fracture patterns, which were either open or closed. Most fractures in this study were closed fractures, accounting for 44 (77.2%) patients. Winquist [4] had the highest frequency of 22 (50%) patients, followed by 16 (24.6%) patients with comminuted fractures and 13 (20%) patients with segmental fractures. This is similar to a study conducted in Jos, Nigeria, by Amupitan I in 2015 [1]. Open fractures accounted for 19 (33.3%) patients, with Gustilo-Anderson Grade IIIA being the most frequent, found in 13 (22.8%) patients. A similar finding was reported by Ikem IC et al. in 2006 [6].

The serum lipid profile for both femoral vein and cephalic vein were computed for open fractures, closed fractures, and the fracture patterns, showing no statistically significant difference between these two variables.

A total of 87.6% of patients sustained a single long bone fracture, while 12.4% sustained multiple long bone fractures. Single long bone fractures were the most common presentation in this study, with the tibia followed by the femur being the most commonly fractured bones. Similar findings regarding bone involvement were observed when comparing male and female patients in this study. The tibia had the highest incidence of fractures, with 37 (64.9%) patients, of which 21 were male and 16 were female. The tibia, being the most distal long bone of the body and largely subcutaneous, is therefore more prone to fractures. A similar finding was reported in a study conducted in this environment by Ikem et al. in 2001 [3, 6].

The mean concentrations of serum lipids for both femoral and cephalic veins were determined. When comparing preoperative mean values to intraoperative and postoperative mean values, the results showed that in 92% of patients, femoral vein serum lipid concentrations increased gradually and steadily intraoperatively, followed by a steady drop within 72 h. A similar finding was reported by Jain et al. in 2008 [5], who observed a moderate increase in lipid concentrations intraoperatively in 97% of cases [9, 13].

The cephalic vein serum lipid profile showed a gradual and steady rise in lipid concentrations preoperatively, intraoperatively, and postoperatively in 76% of patients, except for HDL, which dropped after 72 h postoperatively. HDL is mostly consumed by the liver during lipid metabolism while transporting triglycerides (TG), low-density lipoproteins (LDL), and total cholesterol (TC) to the liver for processing. However, the liver continues to produce HDL for the transport of other lipids for further metabolism. The rise in systemic serum lipid concentrations could be attributed to microglobules escaping pulmonary circulation through pulmonary pre-capillary shunts or via a persistent foramen ovale. These factors may cause a second-hit effect in the lung or a first-hit effect in other systems of the body.

There was a marginal elevation of femoral vein serum lipid concentrations compared to cephalic vein serum lipid concentrations preoperatively, intraoperatively, and postoperatively. In this study, none of the patients had serum lipid levels exceeding the reference range for lipid profile concentration. The results for femoral and cephalic veins were compared using a Student's t-test at a p-value of <0.05, showing a statistically significant difference when comparing preoperative values to intraoperative and postoperative values for both femoral and cephalic veins. However, when comparing femoral vein serum lipid values to cephalic vein values, no statistical difference was found between the serum lipid concentrations.

It is important to note that substantial elevation of serum lipid profile is not clinically significant, as most patients in this study had elevated serum lipid levels without subclinical or clinical features of fat embolism syndrome. This is similar to findings in a study conducted by Giannoudis et al. in 2006 [9]. The most likely cause of FES remains controversial. In this study, significant elevation of serum lipids and the presence of fat macroglobules were observed during reamed intramedullary nailing of acute long bone fractures, aligning with biochemical and mechanical theories, respectively.

Reamer and nail sizes were selected based on the diameter of each patient's medullary canal. Comparison of the largest reamer and nail sizes with serum lipid levels showed no significant correlation ($p > 0.05$), indicating that instrumentation size did not influence lipid concentration. All groups demonstrated a similar transient lipid elevation pattern without clinical evidence of fat embolism syndrome (FES). An incidental finding of fat macroglobules was noted in a patient with bilateral femoral fractures who developed transient, subclinical FES intraoperatively. Following serial reaming and nailing, the patient experienced desaturation (SpO_2 68%), mild fever (37.8°C), hypotension (80/50 mmHg), tachypnea (35 cpm), and tachycardia (102 bpm). Symptoms resolved within 30 minutes after prompt resuscitation with oxygen, intravenous fluids, analgesics, antibiotics, and hydrocortisone. The patient remained stable thereafter. No other patient exhibited postoperative deterioration; mild intraoperative changes in vital signs observed in most cases were attributed to fluid preload, metabolic response, or anxiety and normalized immediately after surgery

Similar findings were reported by Mittal et al. in 2008 [5], who observed that FES was more frequently seen among patients with bilateral femoral fractures compared to those with single femur or tibia fractures. This could be attributed to the cumulative effect of reaming two long bones. Bilateral femoral fractures are typically caused by high-velocity energy, which might result in pulmonary injury (e.g., contusion), leading to a compounding effect following reamed intramedullary nailing of acute long bone fractures in the lower limbs.

During the reaming of fractured long bones, damage to the endosteal vessels increases intramedullary pressure, leading to the intravasation of marrow content through the damaged vessels. The marrow content then infiltrates the venous system and is transported into pulmonary circulation, where it becomes lodged, causing mechanical obstruction of the smaller capillaries. This finding supports the mechanical theory developed by Gurd in 1924 [18]. The platelets adhering to the fat macroglobules release various inflammatory mediators, which lead to vasculitis, pneumonitis, and a local inflammatory reaction. This results in localized vasospasm, bronchospasm, ventilation-perfusion mismatch, and capillary congestion, as described by Luff et al. in 1969 [26].

Fat macroglobules are likely the coalescence of fat, bone marrow, and thrombus materials (thromboplastic substances) that are liberated into the femoral vein. Showers of micro or macroglobules have been observed in patients undergoing reamed intramedullary nailing, detected using intraoperative transoesophageal echocardiography as blood flows through the vessels to the heart, or during post-mortem examination. Jan Modig et al. in 2005 [27] also observed that blood samples taken from the central vein during reaming contained different sizes of fat macroglobules, which may play a role in the pathogenesis of fat embolism syndrome. An incidental finding of fat macroglobules in one of our patients in this study measured 15 x 10 x 8 mm. Chemical analysis of the fat macroglobule revealed a very low level of HDL, while triglycerides (TG), LDL, and total cholesterol (TC) were within normal limits. In the body, HDL primarily functions in reverse lipid transport, moving lipids from peripheral circulation to the liver for metabolism. This may explain the observed drop in HDL concentration in both femoral and cephalic vein samples.

V. Limitation

This study has some limitations. First, the results of the serum lipid concentrations of both lower limb fractures may have been a true representative if the sample were taken from a central line. It is possible that taking samples from both femoral veins may affect the serum lipid values for patients with fractures on both lower limbs. Second, there is need for further extension in the duration of study post operatively. Since over 76% of our patients still had persistent elevation of serum lipid profile beyond 72 h following reamed intramedullary nailing of acute long bone fracture. Additionally, serum lipid levels may be altered by the inflammatory response to trauma; however, the level of increase could not be accurately assessed as it was not feasible to obtain true baseline (pre-injury) lipid values as the participants were mostly victims of motor vehicular accidents who were otherwise healthy and had not undergone recent laboratory tests. Lastly, this was a single centre study, and this may limit the generalizability of the findings of this study to other populations.

VI. Conclusion

This study assessed perioperative serum lipid changes in patients undergoing reamed intramedullary nailing for acute lower limb long bone fractures. Femoral vein lipid levels rose intraoperatively and declined by 72 hours, while cephalic vein levels continued to rise postoperatively except for HDL, which decreased. Although these variations were statistically significant, all lipid values remained within normal limits. No significant differences were found between sampling sites or with reamer and nail sizes, indicating a systemic, size-independent lipid response. Reamed nailing thus induces transient metabolic alterations without exceeding physiological thresholds or increasing the risk of clinical fat embolism in stable patients. However, those with multiple long bone fractures may be more vulnerable and require careful perioperative management. One case of subclinical fat embolism highlights the need for intraoperative vigilance and further studies on circulating fat macroglobules.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

Dr Bulus conceptualized the study and contributed to data curation, resource acquisition, and project administration. The methodology was developed by Dr Bulus, Prof Ikem, and Prof Orimolade. Formal analysis was conducted by Dr Yahaya, while the investigation was carried out by Dr Busuyi and Dr Bulus. Dr Bulus was responsible for writing the original draft, with Prof Ikem and Prof Orimolade reviewing and editing the manuscript. Visualization was handled by Dr Bulus, Prof Ikem, and Prof Orimolade. Supervision was provided by Prof Ikem and Prof Orimolade.

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Data Availability Statement

The datasets ANALYZED for this study can be obtained from the corresponding author upon reasonable request.

Figures.

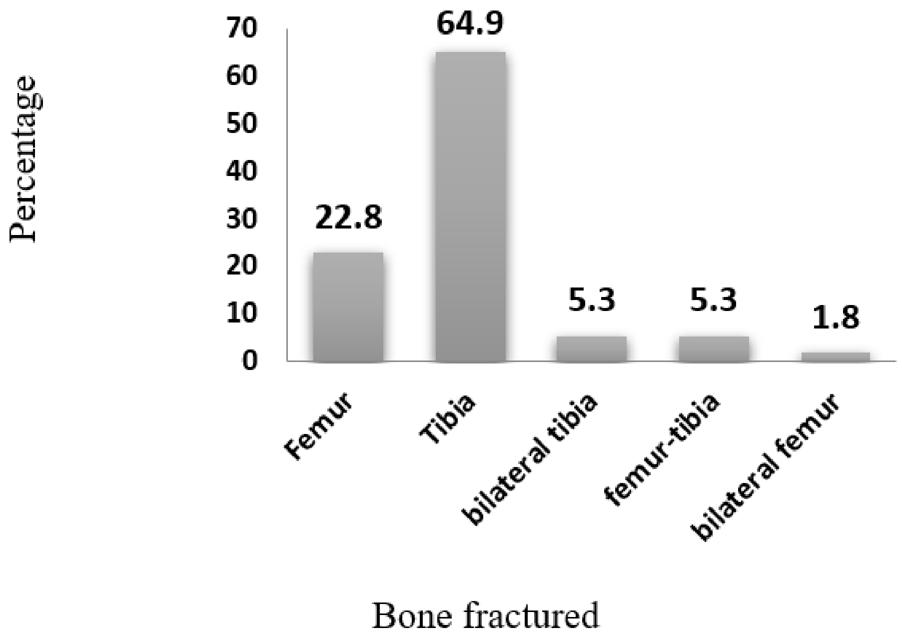

Figure 1. A bar chart showing distribution in the number of bone(s) fracture.

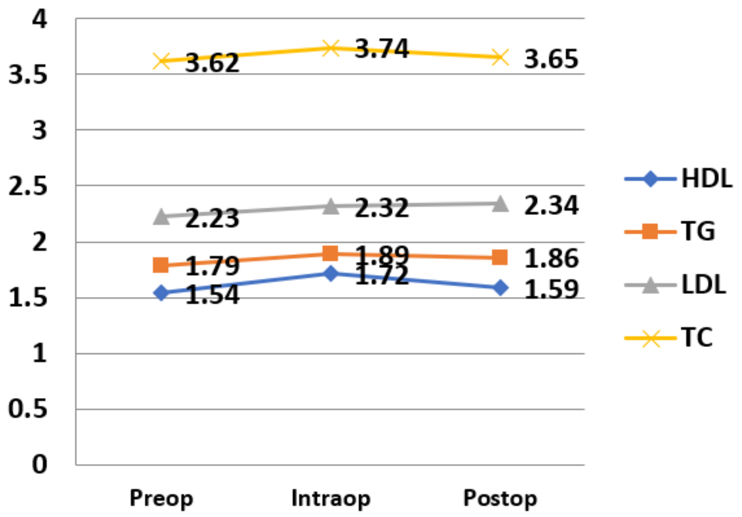

Figure 2: A line graph of the mean concentration of Femoral vein Serum lipid profile preoperative, intraoperative and post operatively.

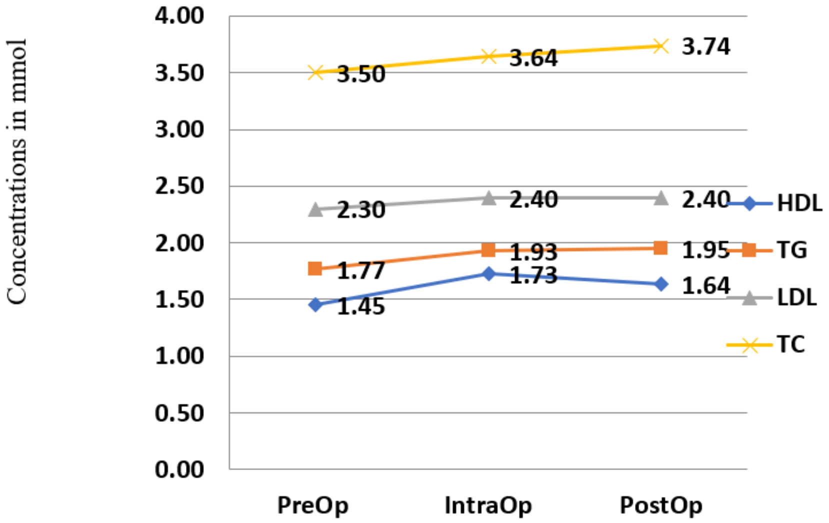

Figure 3. A line graph of the mean concentration of cephalic vein Serum lipid profile preoperative, intraoperative and post operatively.

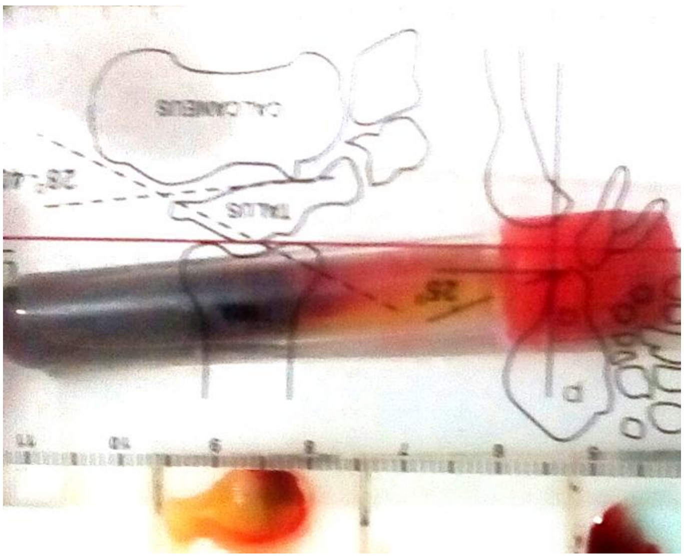

Figure 4. Picture showing macro globules found in a patient.

Table 1. Comparison of preoperative, intraoperative, and postoperative serum lipid levels from the femoral and cephalic veins

		Serum lipids for femoral vein				Serum lipids for cephalic vein			
	Reference value (mmol)	MEAN ± SD	t-statistics	P value	remark	MEAN ± SD	t-statistics	P value	remark
Pre-op HDL	> 1.2	1.54 ± 0.43	4.18			1.45 ± 0.40	4.77		
Intra-op HDL	> 1.2	1.72 ± 0.66	4.77	<0.001	Significant	1.73 ± 0.51	7.84	<0.001	Significant
Post-op HDL	> 1.2	1.59 ± 0.60	3.66			1.64 ± 0.52	6.44		
Pre-op TG	<2.5	1.79 ±0.99	-4.59			1.77 ± 0.94	-5.75		
Intra-op TG	<2.5	1.80±0.94	-4.02	<0.001	Significant	1.93 ± 0.89	-4.66	<0.001	Significant
Post Op TG	<2.5	1.86±0.95	-4.25			1.95 ± 0.97	-4.16		
Pre op LDL	<3.9	2.23 ±0.55	-20.99			2.30 ± 0.53	-20.9		
Intra-op LDL	<3.9	2.31 ±0.57	19.32	<0.001	Significant	2.40± 0.60	-17.2	<0.001	Significant
Post-op LDL	<3.9	2.34 ±0.51	20.99			2.40 ± 0.59	-17.56		
Pre-op TC	2.5 – 6.5	3.62 ±0.73	11.62			3.50 ± 0.72	10.42		
Intra-op TC	2.5 – 6.5	3.74 ±0.72	12.87	<0.001	Significant	3.64 ± 0.76	11.26	<0.001	Significant
Post-op TC	2.5 – 6.5	3.65 ±0.62	13.93			3.74 ± .549	16.89		

Table 2. The vital signs of the patient that developed subclinical features of fat embolism syndrome

	Preoperative	**Before reaming**	**Immediately after reaming /nailing**	**24 h after reaming/ nailing**	**72 h postoperatively**
SPO^2 (%)	99	98	68	98	99
RR (cpm)	20	24	35	26	18
PR(bpm)	88	92	102	86	76
BP (mmHg)	110/80	100/60	80/ 50	100/60	110/80
T (^oC)	36.2	36.8	37.8	37.0	36.8