Effects of Surgical Trauma on Peripheral White Blood Cell Count Following Major Oral and Maxillofacial Surgical Procedures

Philemon Nwabunwene Okolie[1, 2*], Birch Dauda Saheeb[1], Ozoemena Ndubuisi Obuekwe[1] and Ekaniyere Benlance Edetanlen[1]

[1]Department of Oral and Maxillofacial Surgery, University of Benin Teaching Hospital, Benin City, Edo State, Nigeria; and [2]Oral and Maxillofacial Surgery Unit, Dental Centre, Central Hospital, Agbor, Delta State, Nigeria.

***Corresponding author**: Dr Philemon Nwabunwene Okolie. Email: philemonokolie@gmail.com

Abstract

BACKGROUND

The changes in white blood cell (WBC) count after major surgical procedures are well documented in other surgical specialties, but this appears not to be the case in oral and maxillofacial surgery (OMFS). This study aims to determine the effects of surgical trauma on peripheral WBC count following major oral and maxillofacial (OMF) surgical procedures.

MATERIALS AND METHOD

This study was a prospective longitudinal study. The subjects were drawn from all consecutive patients booked at the department of OMFS for elective major OMF surgical procedures at the University of Benin Teaching Hospital, Benin City, Nigeria. Those with underlying medical conditions and diseases and those older than 50 years were excluded from the study. Interviewer-administered questionnaires were used to collect data. Data were collected preoperatively, immediately, then at 24-hr, 72-hr and 120-hr postoperatively. The total WBC and differentials were obtained from the full blood count results, which were analysed with an automated blood cell counter (SYSMEX KX-21 Auto analyser). Seventy-two patients were studied, comprising 51 (71%) males and 21 (29%) females. The age range was four months to 49 years, mean of 15.2 ±1.7 years. Descriptive (range, mean ± standard error of the mean (SEM), frequency) and comparative (ANOVA and Student's T-test) statistics were done. Data were analysed with SPSS version 20 (IBM Inc., Armonk, NY, USA). Significance was set at a P-value of <0.05.

RESULTS

There was a general postoperative increase in total WBC count following major OMF surgeries. The increase peaked at the immediate postoperative period with a gradual decline in subsequent samples in the postoperative 24-hr, 72-hr and 120-hr towards the preoperative baseline values. The decline after 120-hr was, however, at a level slightly higher than the preoperative level. There were significant increases in the total WBC and differential neutrophil counts; there were decreases in the differential lymphocyte counts, which were not statistically significant.

CONCLUSION

Evaluating the patients postoperatively using serial WBC counts may be worthwhile. This is because it may be predictive of the onset of infection or other causes of increased WBC count that may require urgent attention to ensure optimum wound healing after OMF surgery.

Keywords: *Surgical Trauma; White Blood Cell; Count; Major; Oral Maxillofacial Surgery*

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Introduction

There is a continuous increase in major oral and maxillofacial (OMF) surgical procedures in developing countries due to poverty, lack of awareness and late presentation of patients to healthcare facilities for treatment.[1,2] Oral and maxillofacial surgery (OMFS) is a surgical specialty expanding its frontiers of surgical anatomic definition involving a range of surgical procedures and adjunctive treatment of diseases, injuries and defects. It encompasses the functional and aesthetic aspects of the hard and soft tissues of the OMF region. [2,3,4] While there are different criteria for classifying OMF surgical procedures into minor or major, a common criterion used in literature is that which classified OMF surgeries into minor or major based on the use of local anaesthesia or general anaesthesia respectively.[2,5]

The immune system largely depends on white blood cells (WBCs). There are five basic white blood cell (WBC) types: neutrophils, eosinophils, basophils, lymphocytes and monocytes, with each type having a specific role or immune function. As the immune system's "army", WBCs defend the body against microorganisms and foreign substances.[6] Following surgery, whether minor or major, the responses are that of acute increases (occurring within minutes to hours) in the WBC count. The changes are, however, more profound with major surgeries.[7,8] The changes in the different leucocyte counts following either physical or psychological stress have been utilised to measure the physiological stress response.[7] Surgical stress elicits a characteristic response involving the increased circulating concentrations of stress hormones such as cortisol and catecholamines.[9] This is known to activate mature granulocytes in the bone marrow and tissues to rapidly release cells from the margins of blood vessel walls, spleen or bone marrows where they are stored by a process called demargination, as leucocytes spend most of their life in these storage areas.[9] This process of demargination eventually increases the circulating pool of leucocytes in the blood.[9,10]

The effects of major surgical trauma on peripheral WBC count have been extensively studied in developed countries in various specialties such as orthopaedic surgery, cardiovascular and thoracic surgery, and abdominal and urological surgery. These studies documented the increased neutrophil and decreased lymphocyte counts [7, 11-16], whereas monocyte, eosinophil and basophil counts were not significantly altered by surgery. [17, 18]] While changes in white blood cell counts are well documented in other surgical fields, this is not the case in OMFS in our environment. This study aims to determine the effects of surgical trauma on peripheral WBC count and differential neutrophil and lymphocyte counts following major OMF surgical procedures.

Materials and Method

The informed consent and ethical approval for this study were obtained from the patients and the institution's Ethics and Research Committee (No: ADM/E.22A/VOL. VII/354), respectively. This study employed a prospective longitudinal study design on patients (aged four months to 49 years) who had major OMF surgeries between May 2011 and February 2012 in our hospital. Included in the study were all elective cases operated on under general anaesthesia. Excluded from the study were pregnant women patients and patients with the following contraindicating medical conditions or whose medical treatment precludes further surgery: blood disorders and malignancies, HIV and other viral infections, immunosuppressive and chemotherapeutic medications, autoimmune diseases, radiation therapy, who had combined surgeries such as maxillofacial and orthopaedic surgeries, who had blood transfusion either preoperatively, perioperatively or postoperatively. Also excluded from the study were patients with endocrine diseases such as diabetes mellitus and hyperthyroidism and patients with preexisting bacterial infections such as osteomyelitis and oro-facial space infections. Patients who scored higher than 14 in a helminthic evaluation using the parasite evaluation questionnaire [19] and patients hospitalised for more than ten days were also excluded. Using the sample size formula for a descriptive study, [20] we arrived at a sample size of 70 subjects to form a meaningful statistical deduction.

We collected preoperative blood samples from each patient for WBC count, then immediately after surgery at the time skin closure was complet**ed.** This we did at intervals of 24-hr, 72-hr and 120-hr postoperatively. The total WBC and differential counts were obtained from the full blood cell count results, which were analysed with an automated blood cell counter (SYSMEX KX-21 Auto analyser, Sysmex Corporation, Kobe, Japan). We reran the same samples with another automated cell counter to confirm the results' precision. Furthermore, manual differential counts on stained blood smears were done to check the accuracy of the results**.** Data collected for analysis were bio-data, type of surgical procedure, and WBC levels. Categorical data were summarised as frequencies and percentages, while the continuous data were summarised as range, means and standard deviation. The normality of continuous data was tested with the Shapiro-Kowalski test. A one-way variance (ANOVA) test was used to analyse the difference between the measurement means. Data were analysed with SPSS version 20 (IBM Inc., Armonk, NY, USA). A P-Value less than 0.05 was considered statistically significant.

Table 1:
Diagnostic Indications for Major Oral and Maxillofacial Surgery (OMFS)

Indication for surgery	Frequency (n)	Percentage (%)
Ameloblastoma	2	2.7
Central giant cell granuloma	1	1.4
Mandibular fracture	17	23.6
Cleft lip	16	22.2
Cleft palate	18	25.0
Sublingual dermoid	1	1.4
Exposed reconstruction plate	2	1.4
Ossifying fibroma	1	1.4
Osteoma of the Zygoma	1	1.4
Fibrous dysplasia	1	1.4
Dentigerous cyst	1	1.4
Pleomorphic adenoma of the palate	1	1.4
Radicular cyst	2	2.8
Ranula	2	2.8
Trismus2^0 to mandibulectomy/reconstruction	1	2.8
Middle face/Zygomatic complex fracture	5	6.9
Total	72	100.0

Results

Seventy-two (72) out of 101 patients initially recruited for the study who met the inclusion criteria completed the study representing a response rate of 71.3%. Fifty-one (71%) were males, while 21 (29%) were females. The age range was four months - 49 years. The mean age was 15.2 ± 1.7 years (SEM). The patients in the age group of 4 months-5 years constituted the most prominent (38.9%) population. Table 1 shows the indications for OMF surgical procedures. Cleft palate (25.0%) was the most common indication for surgery, followed by mandibular fracture (23.6%) and cleft lip (22.2%). The effects of major OMF surgical procedures on total WBC count are shown in Table 2. Increases in the postoperative total WBC counts were observed in all the procedures. The increase peaked at the immediate postoperative period (POP) with a gradual return to the preoperative baseline value. The changes were statistically significant except for cleft lip repair and enucleation (Table 2). At 72-hr and 120-hr postoperative periods, the increases were no longer significant.

Table 3 shows the effects of OMF surgical procedures on the neutrophil count. There was a significant increase in the mean neutrophil count in the immediate POP ($P<0.05$) in all the procedures except for enucleation. This was still significant at the 24-hr POP for cleft palate repair ($p=0.0001$); ORIF with bone plating ($p=0.037$); ORIF with trans-osseous wiring ($p=0.021$); plate revision ($p=0.020$) and surgical excision ($p=0.006$). Only cleft palate repair ($p=0.008$) was significant at 72-hr POP. At 120-hr POP, the increase was no longer significant in all the procedures.

Table 2:
Effect of Major Oral and Maxillofacial Surgical Procedures on Total WBC Count

Procedure	N	Preoperative (x $10^3/\mu L$)	Postoperative (x $10^3/\mu L$)				
			Immediate	24-hr	72-hr	120-hr	P-value btw the groups
Cleft lip repair	16	11.2±1.00	13.36±1.26	12.89±0.92	11.91±0.94	11.67±0.94	0.552
Cleft palate repair	18	7.82±0.59	11.88±0.96*	11.06±0.80*	9.93±0.75	8.73±0.72	0.002
Mandibulectomy (segmental)	2	3.80±0.00	12.30±0.00	9.40±0.00	6.50±000	6.60±0.00	-
ORIF (with bone plating)	12	6.33±0.43	11.52±0.93*	8.62±0.71	7.05±0.48	6.84±0.29	0.0001
ORIF (with transosseous wires)	10	5.87±0.44	10.41±1.03*	9.37±0.82*	6.94±0.71	6.73±0.40	0.0001
Plate revision	3	5.7±0.65	10.57±1.09*	9.07±2.45	7.63±1.00	6.80±0.17	0.042
Maxillectomy (partial)	2	5.50±0.00	18.80±0.00	10.10±0.00	8.10±0.00	8.90±0.00	-
Surgical excision	6	6.63±0.98	11.53±1.25*	11.52±0.90*	8.4±0.66	7.47±0.50	0.001
Enucleation	3	4.70±0.47	10.17±3.44	8.00 ± 1.94	5.87 ± 1.13	6.53±1.27	0.373

All data expressed as mean ± SEM; N, no. of patients, *$P<0.05$ compared with preoperative value.

Table 3:
Effect of Major Oral and Maxillofacial Surgical Procedures on Neutrophil Count

Procedure	N	Preoperative (x $10^3/\mu L$)	Postoperative (x $10^3/\mu L$)				
			Immediate	24-hr	72-hr	120-hr	P- value btw the groups
Cleft lip repair	16	5.24±0.63	8.67±1.18*	8.53±0.99	7.38±0.77	6.76±0.72	0.045
Cleft palate repair	18	2.79±0.37	7.60±0.83*	7.45±0.70*	.75±0.60*	4.73±0.43	0.000
Mandibulectomy (segmental)	2	1.40±0.00	8.90±0.00	5.90±0.00	4.00±0.00	4.00±0.00	-
ORIF (with bone plating)	12	3.17±0.34	8.12±0.87*	5.64±0.73*	4.23±0.48	3.58±0.36	0.000
ORIF (with transosseous wires)	10	3.27±0.32	6.83±0.71*	6.04±0.87*	3.58±0.65	3.34±0.30	0.000
Plate revision	3	3.23±0.73	6.07±0.95*	6.67±2.82*	4.93±0.94	3.87±0.07	0.044
Maxillectomy (partial)	2	2.70±0.00	14.80±0.00	6.40±0.00	4.60±0.00	4.40±0.00	-
Surgical excision	6	3.15±0.67	8.07±1.59*	8.28±1.40*	4.68±0.88	3.83±0.48	0.005
Enucleation	3	2.57±0.83	6.27±3.43	4.60±1.76	2.43±0.98	3.03±0.93	0.568

All values are expressed as mean ± SEM; *P<0.05 compared to the preoperative baseline values.

Table 4:
Effect of oral and maxillofacial surgical procedures on lymphocyte count

Procedure	N	Pre-operative (x $10^3/\mu L$)	Post-Operative (x $10^3/\mu L$)				
			Immediate	24-hr	72-hr	120-hr	P value btw the groups
Cleft lip repair	16	4.58±0.36	3.77±0.47	3.43±0.48	3.39±0.28	3.85±0.34	0.214
Cleft palate repair	18	4.22±0.42	3.48±0.49	2.76±0.35	3.14±0.37	3.23±0.40	0.143
Mandibulectomy (segmental)	2	2.10±0.00	2.60±0.00	2.50±0.00	2.00±0.00	2.20±0.00	-
ORIF (with bone plating)	12	2.51±0.22	2.8±0.42	2.31±0.13	2.19±0.14	2.65±0.16	0.390
ORIF (with transosseous wires)	10	2.49±0.35	2.79±0.55	2.54±0.35	2.65±0.27	2.60±0.22	0.982
Plate revision	3	1.73±0.32	1.97±0.09	1.63±0.37	1.90±0.15	2.20±0.17	0.546
Maxillectomy (partial)	2	2.30±0.00	3.20±0.00	3.10±0.00	2.80±0.00	3.00±0.00	-
Surgical excision	6	3.23±0.76	2.75±0.45	2.38±0.49	2.70±0.45	2.82±0.40	0.849
Enucleation	3	2.60±0.64	3.17±0.62	2.60±0.20	2.77±0.67	2.93±0.35	0.682
All values are expressed as mean ± SEM.							

The effects of OMF surgical procedures on the lymphocyte count are presented in Table 4. There was an apparent decrease in the mean lymphocyte count, which was most pronounced at the 24-hr POP though not statistically significant. After that, there was a gradual rise towards the preoperative count at 72-hr and 120-hr postoperative samples. The result showed decreases in the mean lymphocyte count in the immediate postoperative periods after cleft lip, cleft palate repair and surgical excision, with a further decrease during the 24-hr period. After that, there was a gradual rise towards the preoperative count. These changes were, however, not significant.

Discussion

Surgery generally aims to achieve an optimal quality of life for the patient. Minor oral surgeries such as tooth extraction cause less trauma and WBC response than major surgical procedures. [7]

The normal physiological response of an initial increase in WBC count after surgery is necessary for wound healing.[21] The assessment of changes in WBC differentials, such as neutrophils, lymphocytes, or the ratio of neutrophil-lymphocyte counts in peripheral blood, has been identified as an easy, simple, inexpensive, and reliable prognostic index to determine host immunity. Thus it can be used to monitor a patient's progress postoperatively. [13,14,22] This can be readily ascertained from the WBC differential count from the full blood count (FBC) result with an automated cell counter, which also offers the advantage of higher accuracy and speed over manual techniques. [23] There is an association between stress and impairment of the immune system in man. Moreover, stress affects WBCs qualitatively and quantitatively. [24] Alterations in the absolute number of circulating WBC differentials have also been associated with physical stress, such as surgical trauma, psychological stress, or malignancy. [25-27]

The predicting effect of WBC count has assumed a prominent role in the overall management of the surgical patient in recent surgery practice. This has led to diverse research in various surgical specialities such as neurosurgery, cardiovascular, orthopaedics, abdominal, urological and gynaecological surgery to evaluate the effect of regional procedures on the white blood cell count.[7,11-16] While there seems to be some form of consensus of opinion on the association between white blood cell count and surgical stress, there is a paucity of information on the effect of major OMFS on white blood cell count to allow for comparative study.

Trauma to the maxillofacial skeleton was a primary reason for patients' presentation, with mandibular fracture (23.6%) being the second most common indication for surgery. This finding is similar to that of a previous Nigerian study [2] that reported 27.6% as the highest indication for maxillofacial surgery. This study revealed the changes in the WBC count following cleft lip repair, cleft palate repair, open reduction and internal fixation (ORIF) using titanium bone plates, ORIF using transosseous wires, surgical excision, enucleation, mandibulectomy, maxillectomy, and plate revision. There was also a post-surgical increase in white blood cell count following major OMFS. It showed that neutrophil is the primary cell type contributing to the overall increase in the WBC count. The initial increase peaked at the immediate POP, after which there was a gradual return to the standard preoperative baseline value with time. This supported the earlier findings reported in some major abdominal and gynaecological surgeries among Nigerians [8] and cardiovascular and orthopaedic surgeries among Caucasians. [12, 13]

There was a significant increase in mean total WBC count following cleft palate repair, ORIF with bone plating, ORIF with transosseous wiring, plate revision and surgical excision in the immediate POP. Previous researchers have reported similar findings of a significant increase in WBC count in cardiovascular, orthopaedic, abdominal, gynaecological, and urological surgeries. [7,11-16] This could be related to the increased production of the stress hormone cortisol, which causes an increased release of neutrophils from the bone marrow, leading to a marked increase in the peripheral neutrophil, which then increases the total white blood cell count. When compared to the preoperative and subsequent postoperative values, the spike in the immediate POP could be linked to the acute stress response following surgery.

The significant increase in total WBC count was sustained until the 24-hr postoperative period in cleft palate repair, ORIF with transosseous wiring and surgical excision. Other procedures did not show a significant increase in WBC count after the 24-hr POP until the 120-hr POP. This finding can be compared to a previous study done among Nigerians [8], which observed that the WBC count was no longer significantly raised after 24 hrs till the seventh postoperative day. Perhaps this observation is related to the magnitude of surgical trauma experienced by the patients in the various procedures.

Previous studies have reported that after major surgery, there is a significant increase in the circulating neutrophil count [9, 10] in the immediate POP. This study's findings agree with this observation, as there was a significant increase in neutrophil count in the immediate POP in all the OMF surgical procedures except for cyst enucleation. The significant increase also extended to the 24-hr POP in cleft palate repair, ORIF with bone plating, ORIF with transosseous wiring, plate revision and surgical excision. Cleft palate repair was the only procedure with a significant increase in the mean neutrophil count at the 72-hr POP. The reason for this observation in neutrophil response following major OMFS could be related to the theory that increased cortisol release following the stress of surgery leads to a pooling of neutrophils from the bone marrow into circulation. [9, 10]

Major OMF surgical procedures induced no consistent changes in the number of circulating lymphocytes. The observed decreases in lymphocyte counts gradually returned to the preoperative values. Similar findings have been described in African and Caucasian [28] patients who had other regional surgeries. [7, 11-16] The decreases in lymphocyte count following major OMF surgical procedures were insignificant. This seems to give credence to the findings that significant changes by a continuous decrease in lymphocyte count after major surgery is a potential indicator of surgical site infection. [28]

Study Limitations

Some of the limitations of this study include screening patients for helminthic infestation, which was only subjective as the presence of chronic parasites may have been found if objective laboratory and stool culture had been done. There were few patients for analysis in maxillectomy and mandibulectomy as most of the cases not included in the analysis had perioperative blood transfusions or had surgery for malignant OMF tumours. The inability to determine the potential effects of the type of anaesthetic agent and the depth of anaesthesia on circulating white blood cells was also a limiting factor. Comparative discussion on the effect of major OMF surgical trauma on the WBC count of African subjects could not be done due to the paucity of studies available in the African and Caucasian sources.

Conclusion

The total WBC and differential neutrophil count increased significantly, while the differential lymphocyte counts decreased but was not statistically significant following major

OMF surgical procedures. Evaluating the patients postoperatively using serial WBC counts may be worthwhile as they may be predictive of the onset of infection or other causes of increased WBC count that may require urgent attention to ensure optimum wound healing after surgery.

Authors contact emails

Philemon Nwabunwene Okolie - Email: philemonokolie@gmail.com
Birch Dauda Saheeb - Email: dauda2000@yahoo.com
Ozoemena Ndubuisi Obuekwe - Email: oxobuekwe@yahoo.com
Ekaniyere Benlance Edetanlen - Email: ehiben2002@yahoo.com

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