Original Article

Role of Interleukin-6 and Bells Adjustment Inventory Scoring in Evaluating Stress on Surgeons during Surgery

Hariprasad Kanakapura Veerendranath[1], Preethi B L[2]

Background and Objectives : Stress is a major public health problem in our society and Health Care Workers are subject to high levels of stress at the workplace[1]. Interleukin-6 (IL-6) is a pleiotropic cytokine and has been shown to be stress responsive. Our objective was to evaluate IL-6 as a marker of stress in surgeons when measured before and after performing a surgery and corelate the same with their individual adjustment score using Bells Adjustment Inventory (BAI) questionnaire.

Materials and Methods : In 40 Subjects were enrolled in our study, 20 surgeons and 20 of the study subjects in control group were non-health care workers performing clerical work. BAI questionnaire was administered to both groups and their morning blood sample collected and IL-6 measured as a baseline. In addition, surgeons blood sample was collected a second time after they performed a surgical procedure.

Results : It was observed that IL-6 (pg/ml) levels at baseline in Surgeons was found to be higher in comparison to control subjects, possibly indicating higher stress levels among surgeons even at rest during routine work period. Our study revealed that surgeons with greater than 5 years of experience had a lesser increase in their postsurgery IL-6 levels in comparison to junior surgeons. Regarding BAI scores, in the health domain surgeons had a better and statistically significant adjustment in comparison to controls. In the overall total adjustment scores, controls, control subjects had significantly better scores.

Conclusion : We found that the baseline IL-6 values were higher in surgeons in comparison to controls, in addition, our study demonstrated an increase in the IL-6 levels postsurgery. Therefore, we can conclude that IL-6 can be an effective marker of acute stress for further research in larger studies.

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Key words **: Interleukin-6, Stress, Surgeons.**

Stress is considered a major public health problem in our society and Health Care Workers are subject to high levels of stress at the workplace. Virtually anything that places special psychological or physical demands upon a person, anything that can potentially cause imbalance in their equilibrium can be considered Stress[2].

Work-related Stress is a potential cause of concern in Health Care Workers and is associated with poor job satisfaction, increase in sick days, anxiety, poor sleep which in turn could lead to medical errors and near misses[3].

Among European Health Care Workers stress represents one of the biggest challenges for health and safety at work affecting 22%[4].

Burnout can affect physicians' satisfaction with their work and the quality of medical care they provide. Increasing evidence suggests that physician burnout can adversely affect patient safety and quality of patient care and contribute to medical errors[5-9].

Editor's Comment :

- Interleukin-6 (IL-6) has been identified as a potential biomarker of stress of all kinds. Further research into IL-6 could provide insights into the physiological impact of stress, potentially informing strategies to mitigate burnout and improve overall well-being in high-pressure environments.

Surgeons appear to suffer higher levels of stress. This can potentially lead to anxiety, depression, problems in interpersonal relationships, alcohol dependency and in rare cases self-harm[10].

IL-6 has been shown to rise following acute stressors such as a speech task, mirror tracing and exercise. Physiological mechanisms underlying stress-related alterations in IL-6 levels involve the interdependent relationship of IL-6 and the Hypothalamic-pituitary-adrenal (HPA) axis. Central and peripheral catecholaminergic systems may also be involved in the regulation of IL-6[11].

Mouse models, have shown that Interleukin-6 (IL-6) is the dominant cytokine inducible upon acute Stress alone. Stress-inducible IL-6 is produced from brown adipocytes in a beta-3-adrenergic-receptor-dependent fashion[12].

M S Ramaiah Medical College, Bengaluru, Karnataka 560054

[1]MD (Emergency Medicine), Assistant Professor, Department of Emergency Medicine and Corresponding Author

[2]MD, Professor, Department of Physiology

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IL-6 has a broad effect on cells of the immune system and beyond and often displays hormone-like characteristics that affect homeostatic processes[13]. Elevated levels of pro-inflammatory cytokines, such as IL-6, have been noted in the development of common mental health problems[14]. O'Donovan, *et al* suggested that clinically anxious individuals have lower morning cortisol and elevated IL-6 levels in comparison to non-anxious individuals, highlighting a potential pathway by which anxiety may increase risk of inflammatory diseases and found a relationship between negative emotions and biological responses[15].

Several clinical evaluation questionnaire scales have been developed to assess a patient's degree of Anxiety and Depression. The Bell Adjustment Inventory (BAI) is a test to assess an individual's adjustment or coping skills and by logical inference, his/her coping mechanisms for stress. Adjustment is the main component of human life. It is the process of finding and adopting modes of behavior suitable to the environment or to the changes in the environment.

Identification and evaluation of stress amongst surgeons will help in mitigating Stress related burden on health care workers. Surgeons working Operation Theatres are subjected to high Stress and anxiety environment, their Stress levels before surgery and after surgery can be evaluated. We planned to evaluate the impact of acute Stress in Surgeons and see if IL-6 levels change during this acute Stress task in a presumably high anxiety environment. We hypothesized that increased IL-6 may be seen in Surgeons when subjected to acute Stress condition like the one experienced by a surgeon during surgery. The IL-6 levels and BAI scores in age matched control group of non-health care workers can act as a reference for comparison.

Aims and Objectives

The primary objective of the study was to evaluate IL-6 levels before and after surgical stress in Surgeons. The secondary objective was to assess personality of individual's adjustment score using BAI questionnaire & IL-6 in surgeons and Non-surgeons (Control).

Materials and Methods

Our study has a case-control design with data acquired prospectively and was conducted at MS Ramaiah Medical College and Hospitals, Bengaluru. The study was approved by the Institute Scientific and Ethical Committees with due considerations to face the potential ethical challenges, a written informed consent was obtained for study participation. After setting significance level at 5% or 0.05, we considered logistical and ethical issues and as ours was a pilot study, sample size needed was 40 and they were enrolled for the study after a written informed consent was obtained. The study participants were 20 Volunteer Surgeons from the same institute and controls were 20 non-healthcare workers in the same hospital. At base line, all the healthy study subjects' clinical parameters were evaluated for inclusion and exclusion criteria. Bells Adjustment Inventory (BAI) questionnaire was administered to all participants and their morning blood sample collected and baseline IL-6 levels measured. The type of surgery scheduled was blinded to investigators to avoid bias. In addition, Surgeons' blood sample was collected a second time after they performed a surgical procedure. The blood sample (3ml) were drawn and collected in EDTA vaccutainers and Plasma stored at 4^{o}C and IL-6 levels measured using standard ELISA kit (EIA IL-6, Immunotech). The BAI questionnaire was received back and analysed whilst maintaining confidentiality. Statistical methods, the collected data was entered in Microsoft Office Excel sheet and data were analysed using the Statistical Package Python software (version 3.7). Student t test was used to know the difference Surgeons *versus* Control with respect to age and Pre-op IL-6. Paired t-test was used to analyse the Pre-op IL-6 before and after intervention. Mann Whitney test was used to analyse the BAI Total Adjustment score.

Test Description :

Bell published his Adjustment Inventory in 1934 with an aim to measure adjustment of students. It is suitable for the use of both genders. He calculated the reliability by the "odd-even" technique and test-retest method. It was validated against Bereuter Personality Inventory. The present Adjustment Inventory was prepared in 1968. This inventory includes four parts-Home, Health, Social and Emotional. Each part has 35 statements, which are answered in 'Yes' and 'No'[16].

The Adjustment Inventory has four parts. Each part has 35 statements. For each Yes' response 1 score is to be given. The total number of 'Yes' scores thus making the total score of the individual in the part. The inventory is a totally negative inventory. When an individual answers in Yes it indicates his/her difficulties. If he/she answers in 'No,' it indicates that the individual has no such difficulty. It culminates in a total score reflective of total adjustment score (Table 1).

Table 1 — *BAI Reference Ranges and Interpretation*

Ares of Adjustment	Description	Score Range Men	Score Range Women
Home	Excellent	0-1	0-1
	Good	2-3	2-3
	Average	4-11	4-12
	Unsatisfactory	12-16	13-17
	Very Unsatisfactory	>16	>17
Health	Excellent	0-1	0-1
	Good	2-3	2-4
	Average	4-8	5-9
	Unsatisfactory	8-13	10-14
	Very Unsatisfactory	>13	>14
Social	Very Aggressive	0-2	0-4
	Aggressive	3-6	5-8
	Average	7-15	9-19
	Retiring	16-20	20-24
	Very Retiring	>20	>24
Emotional	Excellent	0-1	0-2
	Good	2-3	3-6
	Average	4-11	7-15
	Unsatisfactory	12-15	16-20
	Very Unsatisfactory	>15	>20
Total Score	Excellent	0-8	0-16
	Good	9-21	17-30
	Average	22-47	31-58
	Unsatisfactory	48-60	59-79
	Very unsatisfactory	>60	>79

Results

In our study the mean age of control subjects was 43.45±8.60 years and Surgeons' 43.70±8.79 years respectively. Male to Female ratio was 2.3:1. The ratio of controls to Surgeons was 1.5:1. It was observed that IL-6 (pg/ml) at baseline was 28.57±17.07 in Surgeons which significantly higher ($p<0.024$) in comparison to control subjects, indicating higher Stress levels among surgeons even at rest during routine work period (Table 2 & Fig 1). Further, upon measuring the IL-6 levels in the Surgeons after they performed surgery, revealed that IL-6 increased after surgery to 29.50±11.46 from pre-surgery values of 28.57±17.08 ($p<0.693$) (Table 3 & Fig 2). The Types of Surgery performed involved one above knee Amputation, one Nephrectomy, Vaginal Hysterectomy, Haemorriods, breast lump, Hernia, Appendicitis etc.

Table 2 — *Observed difference in IL-6 at Baseline Control versus Surgeons*

Variables	Surgeons (N=20)	Control (N=20) Non-Surgeon	p-value
Age	43.7±8.8	43±9.1	0.806
Base Line IL-6 (at rest) (pg/ml)	28.6±17.1	16.1±16.4	0.024

Note : Student 't' test was conducted to analyse the significance difference between Two groups (Surgeons versus Control) with 95% Confidence level Pre-op IL-6 found to be significant (p-value 0.024)

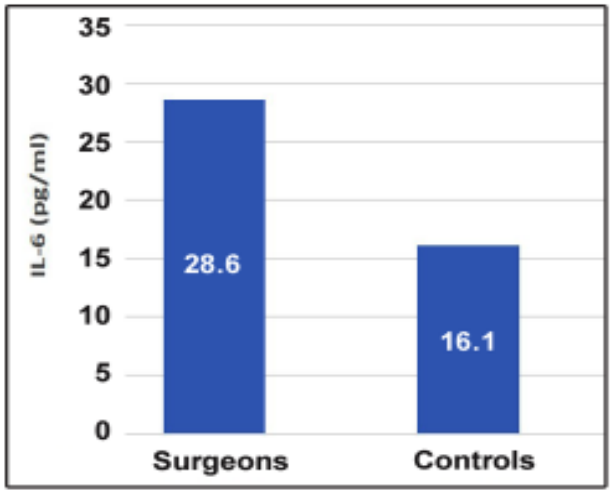

Fig 1 — Observed difference in IL-6 at baseline control *versus* Surgeons

Table 3 — *Comparison of baseline IL-6 and Postoperative IL-6 in Surgeons (Mean±SD)*

Surgeons	IL-6 before Surgery	IL-6 after Surgery	p-value
IL-6 (pg/ml)	28.6±17.1	29.5±11.5	0.693

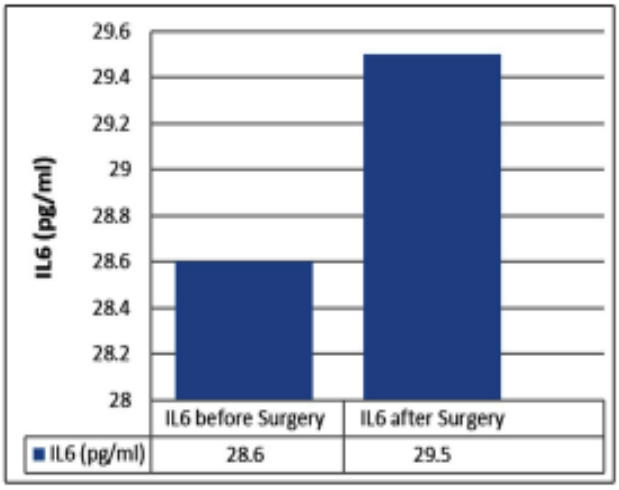

Fig 2 — Comparison of baseline IL-6 and Postoperative IL-6 in Surgeons

When we looked at IL-6 level variation in relation to Stress among Surgeons, we found our study revealed that Surgeons with greater than 5 years of experience had a lesser increase in their postsurgery IL-6 levels ie, 28.59±12.33 and 30.86±10.66 in comparison Surgeons with less than 5 years of experience whose IL-6 levels showed a greater spike from a baseline of 25.76±13.64 to 32.78±21.57 postsurgery. Demonstrating perhaps that Surgeons with more than 5 years' experience had better coping capabilities[17].

BAI personality Scores assessing the individual's adjustment in various domains were as follows. In the domain of home both Surgeons and controls had good adjustment (3.60±3.90 *versus* 2.85±3.91). In the health domain Surgeons had a better and statistically significant adjustment in comparison to controls (4.00±3.52 *versus* 4.85±5.16 p<0.001). However, in the social domain a trend towards higher aggressiveness in Surgeons was observed (6.55±5.32 *versus* 6.30±7.06 p<0.035). Surgeons had better scores in the emotional domain which was statistically significant (4.55±4.48 *versus* 5.55±6.08 p<0.008). In the overall total adjustment scores, control subjects had significantly better scores (25.30±10.29 *versus* 17.05±20.44 p<0.000) (Table 4 and Fig 3).

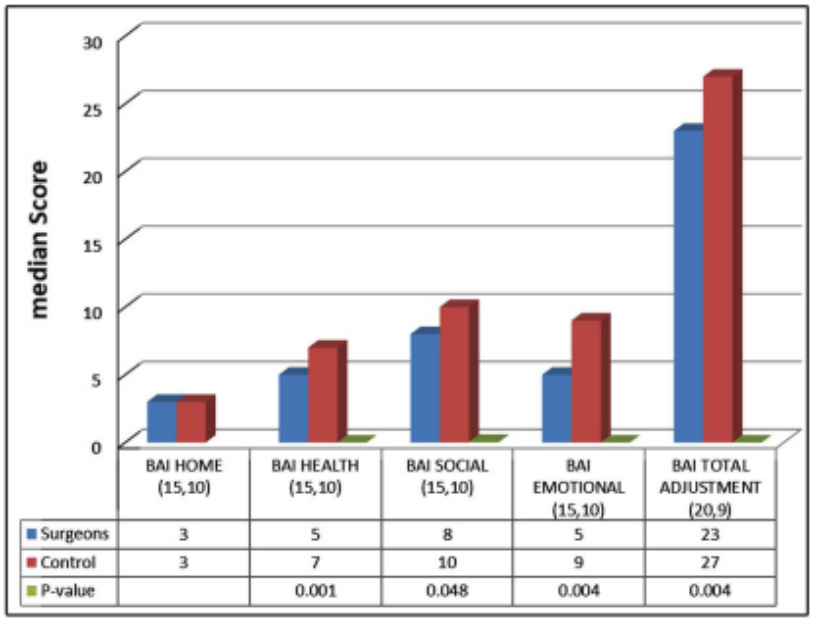

Fig 3 — BAI scores in various domains

The BAI scores among Heath, Emotion and total Adjustment were significantly different between Surgeons and Controls. Overall Surgeons faring significantly better ie, moderate Anxiety levels were much lower compared to controls. In terms of health, emotional adjustment capabilities and overall better coping capabilities (Table 4).

Discussion

Chronic low-grade inflammation, in particular increased concentrations of proinflammatory cytokines such as IL-6 in the circulation, is observed with increasing age. We must note that IL-6 levels increase because of various medical, psychological conditions and life-style choices as well. Research showing that acute as well as Chronic Psychological Stress also increase concentrations of IL-6 supports the notion of a close link between an organism's response to physiological and psychological perturbations. In summary we would further underscore the particular importance of IL-6 as a messenger molecule that connects peripheral regulatory processes with the CNS[18].

Table 4 — *Showing BAI Scoring*

BAI Scoring (Variables) [0-13: Minimal, 14-19: Mild, 20-28 moderate, 29-63: Severe]	Surgeons Median	Control Median	P-value
BAI Home (15,10)	3.0	3.0	0.567
BAI Health (15,10)	5.0	7.0	0.001
BAI Social (15,10)	8.0	10.0	0.048
BAI Emotional (15,10)	5.0	9.0	0.004
BAI Total Adjustment (20,9)	23.0	27.0	0.004

Note : Mann Whitney test was used to analyse the significance difference between two groups (Surgeons versus Control) for above variable with 95% Confidence level Other than BAI Home all the above variables found significant. Interpretation of BAI scores: Grand sum between 0-21 indicates Very Low Anxiety. A grand sum between 22-35 indicates moderate anxiety.

Psychological Stresses were associated with the physiological response such as changes in immunological response and inflammation. Anxiety and Depression contribute to increased risk for disorders with an inflammatory etiology and elevated inflammatory activity may be a significant moderator of emotion-disease interactions[19].

Stress has long been recognised as a significant factor contributing to performance of individuals in aviation, military and competitive sports. In all these fields, specific training interventions have been established. Surgery being a human safety critical domain in which the Surgeon's performance is a crucial determinant for patients' outcome, yet the effects of Stress on medical professionals are seldom acknowledged and formal training to cope with Stress is rarely offered[20].

In a study of Stress in women who reported greater Depression, Anger, Fatigue, or Total Mood disturbance had significantly higher levels of IL-6, and women with greater vigour had lower IL-6 levels. It was observed that Levels of IL-6 were not related to Anxiety or confusion[21,22].

Surgical expertise being complex, Surgeons at large are resilient and are adapted to high Stress

levels compared to other specialities and normal population. Association of Surgeons of Great Britain and Ireland evaluated 1000 members with a postal questionnaire related to occupational stressors, it was observed that major individual stressors were, interference of the job with personal life, general administration and burden of higher number of patients in the clinics. Surgeons showed mean Stress scores significantly higher than the general population on two subscales of the mental health index[23,24].

In our study the Surgeons demonstrated better coping capabilities in comparison to Non-health care Workers, in terms of IL-6 levels and BAI scores. The Surgeons were also seen to cope with the stress of surgery with no significant raise in IL-6 levels before and after surgery. Surgery is a highly pressured field with specific demands. Surgeons characteristically enjoy the stimulating features of their work. The issue of intraoperative stress elicited strong responses in Surgeons, seems particularly to affect non-technical performance: judgment, decision making and Communication. The coping strategies identified were highly specific to intraoperative Stress management. Decision-making pathways and team leadership under acute Stress appear especially important.

Our study involved medical and psychological components. Taking cognizance of this, the authors considered some of the potential ethical issues associated. BAI questionnaire dwells into personal lives of the study subjects which means maintaining confidentiality is paramount. This also meant that the data will not be shared with the hospital administration. The IL-6 levels measurement was done in the research lab using numbered samples to preserve confidentiality. We addressed these challenges by full approval from Institutional Review Board (IRB) obtaining informed consent, implementing confidentiality measures with all data acquired.

Conclusion

Our study was able to demonstrate that IL-6 can be used for evaluation of acute Stress. We found that at baseline IL-6 values were higher in Surgeons in comparison to controls, likely owing to Stress prior to starting work in the Operating Room. In addition, our study demonstrated an increase in the IL-6 levels postsurgery. Therefore, we can conclude that IL-6 can be an effective marker of acute Stress for further research in larger studies. BAI scores also suggests that Surgeons have good coping skills and with greater experience in the surgical field possibly Stress is better managed physiologically. Surgeons develop such coping strategies individually, during their training and subsequent practice through years of Observation and by trial and error. Through this study we would advocate for more structured formal training to develop and instil stress-management strategies among Health Care Workers in general and particularly Surgeons.

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Presentation at a Meeting : Nil

Conflicting Interest : Nil

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