International Journal of
Science Inventions Today
www.ijsit.com
ISSN 2319-5436
Review Article

STRESS RESPONSE TO SURGERY AND ANESTHETIC ROLE

Dr. Anju Ojha*, Prof. Dr. Rui Xia, Dr Xu Wei, Dr. Rakesh Karn, and Dr. Sahana Tamrakar

Department of Anesthesia and Critical Care, The first affiliated Hospital of Yangtze University, Jingzhou, Hubei Province, PR China

ABSTRACT

Stress response to surgery follows the Hypothalamo-Pituitary-Adrenal Axis pathway releasing various hormones. Adrenocorticotropic hormone and cortisol produced during surgery plays a vital role. Both hormones are released few minutes after surgery. Anesthetic agents inhibit ACTH and cortisol production when given prior to surgery. Anesthetic agent has very little effect on cytokine response.

INTRODUCTION

In recent years, it has been suggested that memory seems to occur more frequently during surgical stimulation regardless of anesthesia depth[1]. Following surgical stimulation, stress hormones are released in response to pain which targets the hippocampus, prefrontal cortex and amygdala -areas involved in memory circuits[2].According to recent hypothesis, high concentration of cortisol disrupts the interaction between hippocampus and neo-cortex which impairs memory consolidation, as occur during physiological sleep[3].Exactly how stress or glucocorticoids impair memory is still not well understood. It has been proposed that, stress or glucocorticoids induces various effects, such as change of the after-hyperpolarization amplitude, Calcium current or glutamate transmission which impairs Long Term Potentiation activation[4]. 'Fragementation' an important feature of Post-Traumatic Stress Disorder, in which patient describes gaps in recalled experience following trauma[5].

Sympatho-Adrenal Response:

Hypothalamo-Pituitary-Adrenal Axis mediates changes in response to surgical stress. In response to surgical stress, hypothalamic activation of sympathetic nervous system causes increased secretion of catacholamines from adrenal medulla and release of norepinephrine from presynaptic nerve terminals. This in turn leads to tachycardia and hypertension. Other visceral organs are also affected by efferent sympathetic stimulation[6].

Endocrine Response:

In response to stress, ACTH, Growth hormone (GH), Prolactin (PRL) hormones are secreted from Anterior pituitary gland and ADH from Posterior pituitary gland. In pancreas, glucagon is released and insulin secretion may be diminished.

Stress response to surgery causes an increased production of hormones with catabolic function, which mobilizes substrate to provide energy source.

a) Cortisol: Increase in cortisol level is related to intensity of surgical stimulus[7] and it is detected few minutes after start of surgery. It shows metabolic effect and anti-inflammatory effect[6]

b) Prolactin Hormone: It has little metabolic activity. It regulates T-Lymphocyte proliferation [8].

Cytokine Response:

A complex cytokine cascade activates in response to surgical stimulus. Cytokines are immune mediators that initiates the inflammatory response at the site of injury and infection.

Once the tissue gets injured, pro-inflammatory cytokine are produced by monocytes and macrophages at the site of injury[9]. IL-1 and TNF alpha are produced. They stimulate further production of cytokine IL-6[6, 10]. This phenomenon is known as acute phase response. This manifestation of acute phase response causes fever and tachycardia. IL-6 results in generation of acute phase proteins, including c-reactive proteins[9].IL-6 also produces antiproteinase, fibrinogen[9], neutrophil elastase[11, 12], stimulates proliferation of PMNL progenitors in the bone marrow[13]. High level of IL-6 has been associated with increased severity of tissue trauma[14] and subsequent development of post-operative complications[10].

Microcirculatory Response:

Microcirculatory disturbance is most common in patient who has undergone prolonged hypoperfusion secondary to significant intra-operative blood loss. The initial response is vasoconstriction in response to sympathetic stimulation. Pronounced leucocytes accumulation and adherence to endothelial lining of blood vessel as a result of inflammatory process leads to increased microvascular permeability, rupture of endothelial integrity[15].Combined with the capillary leakage caused by pro-inflammatory cytokines release and increase nitric oxide production[16], the interaction of adhesion molecules lead to cell-cell contact with PMNL attachment, resulting in microcirculatory obstruction and failure of transcapillary exchange. This ultimately leads to cellular hypoxia and accumulation of metabolites.

Metabolic Response:

Major surgery results in reduced metabolism for approximately 24 hours post-operatively, followed by catabolic phase of up to 2 weeks duration and a final anabolic phase. During anabolic phase, increased level of amino acids are required for the synthesis of acute-phase proteins in the liver. The hypothalamic release of CRH causes corticotrophin secretion resulting in raised steroid level[17]. Increased glucocorticoid production inhibits protein synthesis, increase muscular protein degradation and mobilization of fats by lipolysis[17, 18]. It also limits inflammatory reactivity of mononuclear cells and suppress antibody production[18].

Cognitive Response:

Stress hormones play an important role in cognition by affecting hypothalamus. Corticosteroid is the major hormone released during stress and plays a crucial role in cognition. The hippocampus has the highest concentration of corticosterone receptors in the brain [19] High concentration of circulating glucocorticoids, inhibit long term potentiation(LTP) whereas low concentration potentiates LTP[20].

Effect of General Anesthesia on the Stress Response to Surgery:

Anesthetic drugs shows variable action on Hypothalamo-Pituitary-Adrenal hormone secretion but

shows very little effect on cytokine response to surgery[21]. blood level of ACTH, PRL, cortisol, Epinephrine, Norepinephrine are evaluated to detect the stress response[6]. Propofol, Sevoflurane, Opioids, Thiopentone, Neuroleptic drugs stimulate PRL release during anesthesia [6, 22] aceto paola]. Opioids suppresses ACTH and cortisol when given before surgery starts[6, 23]. Etomidate suppresses corticosteroids production by reversibly inhibiting 11-Beta Hydroxylase enzyme at adrenal cortex. Sevoflurane,Propofol suppresses cortisol secretion[24, 25].

Effect of Regional Anesthesia:

Extensive epidural analgesia with Local anesthetic agents will prevent the endocrine and metabolic responses to surgery in the pelvis and on the lower limbs. Blockade of dermatomal segment T4-S5 by epidural analgesia, before starting of surgery, prevented increase in cortisol and glucose concentration in response to hysterectomy[26]. Both afferent input from surgical site to CNS and HPA axis and efferent autonomic neuronal pathways to the liver and adrenal medulla are blocked. Thus adrenocortical and glycemic responses to surgery are abolished.

CONCLUSION

The stress response to surgery comprises a neuronal activation of HPA axis causing a hormonal changes resulting in catabolic state of metabolism. On the other hand, cytokines are produced in response to surgery. Regional anesthesia have better control over adrenocortical and glycemic response compared to GA.

REFERENCES

1. Deeprose, C., et al., Unconscious learning during surgery with propofol anaesthesia. Br J Anaesth, 2004. 92(2): p. 171-7.
2. Cahill, L. and J.L. McGaugh, Mechanisms of emotional arousal and lasting declarative memory. Trends Neurosci, 1998. 21(7): p. 294-9.
3. Payne, J.D. and L. Nadel, Sleep, dreams, and memory consolidation: the role of the stress hormone cortisol. Learn Mem, 2004. 11(6): p. 671-8.
4. Joels, M. and H.J. Krugers, LTP after stress: up or down? Neural Plast, 2007. 2007: p. 93202.
5. Bremner, J.D., Does stress damage the brain? Biol Psychiatry, 1999. 45(7): p. 797-805.
6. Desborough, J.P., The stress response to trauma and surgery. Br J Anaesth, 2000. 85(1): p. 109-17.
7. Nicholson, G., J.M. Burrin, and G.M. Hall, Peri-operative steroid supplementation. Anaesthesia, 1998. 53(11): p. 1091-104.
8. Clevenger, C.V., et al., Regulation of interleukin 2-driven T-lymphocyte proliferation by prolactin. Proc Natl Acad Sci U S A, 1990. 87(16): p. 6460-4.
9. Baumann, H. and J. Gauldie, The acute phase response. Immunol Today, 1994. 15(2): p. 74-80.

10. Baigrie, R.J., et al., Systemic cytokine response after major surgery. Br J Surg, 1992. 79(8): p. 757-60.
11. Hildebrandt, U., et al., Granulocyte elastase and systemic cytokine response after laparoscopic-assisted and open resections in Crohn's disease. Dis Colon Rectum, 1999. 42(11): p. 1480-6.
12. Hildebrandt, U., et al., Comparison of surgical stress between laparoscopic and open colonic resections. Surg Endosc, 2003. 17(2): p. 242-6.
13. Botha, A.J., et al., Early neutrophil sequestration after injury: a pathogenic mechanism for multiple organ failure. J Trauma, 1995. 39(3): p. 411-7.
14. Cruickshank, A.M., et al., Response of serum interleukin-6 in patients undergoing elective surgery of varying severity. Clin Sci (Lond), 1990. 79(2): p. 161-5.
15. Yamauchi, J.I., et al., Role of TNF-alpha in local surgical trauma-induced microvascular dysfunction. Dig Surg, 1999. 16(5): p. 400-6.
16. Bateman, R.M., M.D. Sharpe, and C.G. Ellis, Bench-to-bedside review: microvascular dysfunction in sepsis--hemodynamics, oxygen transport, and nitric oxide. Crit Care, 2003. 7(5): p. 359-73.
17. Singer, M., et al., Multiorgan failure is an adaptive, endocrine-mediated, metabolic response to overwhelming systemic inflammation. Lancet, 2004. 364(9433): p. 545-8.
18. Hill, A.G. and G.L. Hill, Metabolic response to severe injury. Br J Surg, 1998. 85(7): p. 884-90.
19. McEwen, B.S., Corticosteroids and hippocampal plasticity. Ann N Y Acad Sci, 1994. 746: p. 134-42; discussion 142-4, 178-9.
20. Roozendaal, B., G.L. Quirarte, and J.L. McGaugh, Stress-activated hormonal systems and the regulation of memory storage. Ann N Y Acad Sci, 1997. 821: p. 247-58.
21. Kahveci, K., et al., The effect of anesthesia type on stress hormone response: comparison of general versus epidural anesthesia. Niger J Clin Pract, 2014. 17(4): p. 523-7.
22. Hall, G.M., et al., Substrate mobilisation during surgery. A comparison between halothane and fentanyl anaesthesia. Anaesthesia, 1978. 33(10): p. 924-30.
23. Bent, J.M., et al., Effects of high-dose fentanyl anaesthesia on the established metabolic and endocrine response to surgery. Anaesthesia, 1984. 39(1): p. 19-23.
24. Jung, S.M. and C.K. Cho, The effects of deep and light propofol anesthesia on stress response in patients undergoing open lung surgery: a randomized controlled trial. Korean J Anesthesiol, 2015. 68(3): p. 224-31.
25. Marana, E., et al., Neuroendocrine stress response in gynecological laparoscopy: TIVA with propofol versus sevoflurane anesthesia. J Clin Anesth, 2010. 22(4): p. 250-5.
26. Engquist, A., et al., The blocking effect of epidural analgesia on the adrenocortical and hyperglycemic responses to surgery. Acta Anaesthesiol Scand, 1977. 21(4): p. 330-5.