# Cognitive Overload in Surgery

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| *Prepared for:* | Healthcare Professionals, Surgical Trainers, and Policy Makers |
| *subject:* | Understanding and Mitigating Cognitive Overload for Enhanced Surgical Safety and Training. |
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# Introduction

Medical errors are a significant cause of morbidity and mortality, with surgical complications accounting for a substantial number of global deaths annually. The evolution of surgical training, from traditional apprenticeships to modern simulation and competency-based models, reflects an increasing emphasis on patient safety. This document explores the critical role of Cognitive Load Theory (CLT) in surgical education and practice, defining cognitive load, its impact on performance, and strategies for its effective management. Key themes include the types of cognitive load, the physiological stress response, common distractions in the operating room, and the importance of Non-Technical Surgical Skills (NOTSS) for optimizing surgical outcomes.

# The imperative for surgical safety

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| *Prevalence of Medical Errors* | Medical errors are a major public health concern. "Based on 1998 reports, 44,000 to 98,000 annual deaths in America are due to human error." The WHO reports "one million deaths annually globally due to surgical complications." Medical errors are also identified as "the third leading cause of death in America". |
| *Definition of Medical Error* | The IOM Committee on Quality of Health Care defines medical error as "the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim." |
| *Concept of Safe Surgery* | Safe surgery aims to "create a safe system and environment where the patient experiences minimal harm and maximum therapeutic benefit." This requires careful design of conditions before, during, and after surgery, based on Evidence-Based Medicine principles, to prevent errors and ensure positive patient outcomes. |

# Evaluation of surgical training models

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| *Early Apprenticeship (Until 19th Century)* | Training began young (12-13 years old) and lasted 5-7 years, primarily through direct observation and replication without formal guidelines (Barber Surgeons). |
| *Halstedian Model* | Introduced by Dr. William Halsted, this model promoted a "see one, do one, teach one" approach, gradually increasing responsibility and integrating bedside teaching with basic sciences. |
| *Modern Simulation (Post-1999 IOM Report)* | Following the 1999 Institute of Medicine report on medical errors, training shifted towards simulation to prioritize patient safety and adapt to work-hour restrictions. |
| *Competency-Based Surgery (Post-1998)* | Prior to 1998: Training focused on "technical surgical skills." |
| *After 1998* | Emphasized "competency-based surgeon" training, integrating both "Technical Surgical Skills" and "Non-Technical Surgical Skills." |

# Cognitive load theory (CLT) in surgery

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| *Definition of Cognitive Load* | Cognitive load is "the amount of mental effort or resources required to complete a task." It describes the mental resources an individual must allocate to respond to a task's cognitive demands, often characterized as the "limited resources of working memory." |
| *Significance in Surgery* | CLT helps understand how surgeons process information during complex procedures. Managing cognitive resources "can enhance surgical performance, improve training outcomes, and ultimately benefit patient safety." |
| *Cognitive Demands on Surgeons* | Surgeons operate in a "Stress-Based Environment," requiring high cognitive capacity to "make clinical decisions," "manage pressures in the operating room," and "effectively and safely apply technical and non-technical skills." |
| *Executive Functions* | These mental processes (e.g., planning, focusing attention, memorizing instructions, multitasking, emotional regulation) are crucial for surgical success and are "all dependent on cognitive capacity."<br><br>Competency-based training focuses on "skill, knowledge, and performance" within a defined educational period, not merely the accumulation of certificates or time served. |

# Impact of Cognitive Overload and Stress

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| *Consequences of Cognitive Overload* | Can lead to "Stress, Skill, Dexterity, Decision making, Communication, Fatigue..." |
| *Stress Response Systems* | • Sympathetic Adrenal Medullary (SAM) System<br>Releases catecholamines (epinephrine, norepinephrine), with central noradrenaline (NA) rising immediately upon stressor onset.<br>• Locus Coeruleus Noradrenergic System<br>Releases NA to brain regions, including the prefrontal cortex; "Elevated NA levels may decrease prefrontal delay cell activity."<br>• Hypothalamic Pituitary Adrenal (HPA) Axis<br>Stress cortisol release, which crosses the blood-brain barrier and directly influences central processing. |
| *Time Course of Stress Hormones and Bi-Modal Distribution of Negative Effects* | • Immediate Response (First 10 mins)<br>Central noradrenaline rises; "50% of measurements show negative effects during this period" on working memory.<br>• Second Peak (Around 35 mins post-stress)<br>Cerebral cortisol levels peak, causing "50% of measurements [to] show negative effects" on working memory due to glucocorticoid receptor activation and a decline in prefrontal delay cell activity. |

# Managing Cognitive Load

## CLT identifies three types of cognitive load:

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| *Germane Load (Building Schema)* | • Refers to resources dedicated to "learning and strengthening all resources that are in long-term memory."<br>• Involves "strengthening and strengthening Schema" through "repetition and performance of Schema," leading to "task success in an automated manner." This is the productive load that contributes to learning and expertise. |
| *Intrinsic Load* | • This is the inherent "complexity of the surgical procedure itself."<br>• It is heavily influenced by the number of interacting elements in the surgical field that "must be performed simultaneously."<br>• Also depends on the surgeon's "knowledge and information about the type of surgery."<br>• Sustained intrinsic load leads to "optimization of Germane Load and formation of Schema." |
| *Extraneous Load* | • Refers to "unnecessary mental activity" imposed on the surgeon and OR personnel, often due to "poor design in the system or insufficient information during the activity."<br>• It acts as "noise in the system" that interferes with training and working memory.<br>• Caused by "many types of distractions in the operating room." |

# Distractions in the Operating Room

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| *Timing of Distractions* | • Distractions show a "U-shaped distribution pattern," with the highest frequency in the "first (32%) and fourth quartiles (41%) of surgical procedures."<br>• Cumulative interference levels are also highest in the first (849 points) and fourth (1068 points) quartiles. However, the *most disruptive events* (equipment issues and procedural interruptions) occur more frequently in the "second (40.62%) and third quartiles (53.12%)."<br>• A positive correlation exists between total operation time and both the number and level of distractions.<br>• Interference Levels by Distraction Type (on a scale of 1-9): Equipment Issues: Highest average interference score (6.8).<br>• **Procedural Interruptions:** Second highest interference score (6.5).<br>• Case Irrelevant Communication: Moderate interference (3.9).<br>• **Phone/Bleep:** Lower interference (2.3).<br><br>***Insight:*** "While people entering/exiting and case irrelevant communication were the most frequent distractions, they did not cause the highest levels of interference. Equipment issues and procedural interruptions, though less frequent, caused the most significant disruptions to surgical workflow." |

# Non-Technical Surgical Skills (NOTSS)

Effective management of cognitive load and distractions is often achieved through the application of non-technical skills. The NOTSS Taxonomy provides a framework for these crucial abilities, categorized into a three-level hierarchy (categories, elements, and behaviors):

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| *Situation Awareness:* | • Gathering information<br>• Understanding information<br>• Projecting and anticipating future state |
| *Decision Making* | • Considering options<br>• Selecting and communicating options<br>• Implementing and reviewing decisions |
| *Communication and Teamwork* | • Exchanging information<br>• Establishing a shared understanding<br>• Co-ordinating team activities |
| *Leadership* | • Setting and maintaining standards<br>• Supporting others<br>• Coping with pressure |

# Conclusion

Addressing cognitive overload in surgery is paramount for patient safety and effective surgical training. By understanding the types of cognitive load, recognizing the physiological impacts of stress and distractions, and actively managing extraneous factors, healthcare systems can optimize the surgical environment. Emphasizing competency-based training, which includes robust non-technical skills, is crucial for developing surgeons who can effectively manage complex, high-pressure situations, ultimately leading to safer and more efficient surgical outcomes.