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Flow disruptions impacting the surgeon during cardiac surgery: Defining the boundaries of the error space

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ABSTRACT

Background: The aim of this investigation is to place surgical disruptions in a different light. Rather than viewing these disruptions as isolated events which may affect the surgical team, we represent them as an aggregated space which serves to disconnect the team from the task at hand. Furthermore, we make the case that by understanding this error space, one can begin to target interventions that reduce the boundaries of this space and as a consequence reduce the opportunity for errors to develop.
Methods: Trained doctoral-level human factors students observed 24 cardiac procedures for flow disruptions impacting the surgical team and recorded the frequency as well as time needed to resolve these events. Observations were later coded using a human factors taxonomy and descriptive statistics were applied.
Results: A total of 693 workflow disruptions were experienced by the surgical team where interruption issues accounted for the greatest frequency of events (32.61%). Of 139.06 h of total observation time, 10.14 h was needed to resolve the 693 disruptions identified. On average, each disruption took 61.99 s to resolve.
Conclusion: While there is value in identifying the frequency of flow disruptions, this only addresses part of the problem. What is missing from analyses of this sort is the time that the healthcare professional is separated from their central task; in this case the surgeon performing thoracic surgery. This paper provides a conceptual and quantitative metric that allows for the practical application of proactive methods for identifying systemic threats.

1. Introduction

While few relationships are more intimate than that of the physician and patient, successful outcomes in surgery are dependent upon many factors. Perhaps most important is the engagement of the surgeon with the task at hand. Reason (2001) explained that while all surgeons make errors, the best of them have the ability to compensate for any adverse events. Although adaptation to unforeseeable events has been characterized as 'surgical excellence', the ability to be flexible and deploy different modes of adaptation require various cognitive resources.[1] Rather than surgical excellence, it may be more appropriate to refer to this ability as 'surgical resilience'. Resilience then requires that the surgeon have the cognitive wherewithal to identify changes in the status of the surgical environment that are pertinent to the patient or the team and adjust accordingly.

Smith and Hancock's (1995) model for situational awareness can be used to better understand the notion of resilience. Situational awareness exists neither in the surgeon or in the environment, rather it is the result of the actors' externally directed consciousness during the execution of the task. During surgery, the surgeon is constantly sampling the environment for cues as to the status of the operation and adjusting his or hers' actions based upon the interpretation of those cues.[2] While it may be argued that no surgery goes exactly as planned, the result of this externally directed consciousness, in the face of a dynamic task is indeed what we refer to as situational awareness. It is here that process inefficiencies or distractions may have their greatest impact, as they represent cues, not central to the task at hand. Furthermore, as they increase, they use cognitive resources that are better focused on the patient status and the central task.

One way to understand the role of the process inefficiencies is through the investigation of flow disruptions. Multiple studies have investigated flow disruptions in the healthcare industry in an attempt to better understand the nature of process inefficiencies that pose as threats to the system.[3–7] Specifically, these disruptions are often investigated in light of the collective team (threats to the team), rather than the individual disciplines.

Flow disruptions have been defined in the literature as any event which results in the deviation of the natural progression of the task.[3]

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Boquet et al. (2016) proposes that it may be more appropriate to characterize these disruptions, as "threat windows", referring to the accumulation of disruptions over time, which increase the opportunity for errors or adverse events to occur.[7] This notion is illustrated by Wiegmann et al.[3] who found a relationship between flow disruptions and errors during CVOR surgery.[3] Just as important, these threat windows serve to disengage the healthcare professional from the patient.

In an effort to further define the concept of threat windows, Cohen et al.[6] identified disruptions during cardiac surgery and their differential impact on three disciplines: Anesthesia, Circulating Nurse and Perfusion. The study found differences not only in the types of threats experienced by each discipline, but also the time needed to resolve the threats. For example, circulating nurses experienced more coordination and interruption related disruptions than did either anesthesiologists and perfusionists, whereas anesthesiologists and perfusionists experienced more layout issues. In terms of time needed to resolve the disruptions, circulating nurses spent more time resolving coordination issues than the anesthesiologists or perfusionists. However, perfusionists spent more time resolving the layout issues than did anesthesiologists or circulating nurses.[6] This research suggests that in order to develop targeted interventions to address these disruptions, both the individual discipline and time needed to resolve disruptions should be considered.

While much time, effort, and resources have been spent in attempts to identify errors in complex systems such as surgery, the net result of these efforts oftentimes fail to address the foundation for the development of the errors in the first place.[8–10] Quality assurance and safety professionals often find themselves "chasing their tails" attempting to identify the genesis of errors and adverse events rather than attempting to find the system inefficiencies that give rise to these events in the first place. Viewing threat windows as the aggregate of inefficiencies contained within a system may provide an understanding and clarity as to how errors are generated.

Indeed, one can conceptualize the accumulated time needed to resolve these disruptions as the "error space" which represents a cognitive disengagement between the practitioner and the patient. It is within this space that non-relevant cues (i.e., process inefficiencies) disrupt and distract the practitioner from the central task. The act of resolving these flow disruptions changes the task and presents additional, non-relevant cues which may mask salient cues that are important for patient status. It should be noted that the "error space" is not meant to describe "errors", rather it describes the temporal opportunity for errors to occur based on the accumulated process inefficiencies.

Whereas we often view errors as finite commodities (i.e., there were x number of errors during surgery) the same is not true for the error space. As disruptions occur in the system, the error space changes across dimensions and represents an increase in the cognitive distance of the healthcare worker from the patient or task. There is no "perfect procedure" (i.e., zero disruptions taking no time to resolve), in fact, some disruptions allow for the mental reset of the team and may help to avoid task fixation. However, as the disruptions and the time needed to resolve them accumulate, the opportunity for missteps, errors, and oversights increases. Consider Fig. 1, each ring represents 10 s of time needed to resolve an average disruption. Therefore, the further out from center (i.e., perfection) one goes, the larger the error space becomes.

In a perfect world, a given procedure takes a set amount of time within which the provider is completely physically and cognitively engaged with patient. However, when a disruption occurs, there is opportunity for the provider to become disengaged from the patient. This disengagement represents the error space. As more disruptions occur and more time is needed to resolve these disruptions, the error space increases, making it necessary for the surgeon to reestablish the connection with the patient (i.e., pick up where the provider left off).

By defining the error space, we can identify the boundaries of the threat windows which exist within the system. We can use this information as a metric to develop interventions aimed at not only reducing individual disruptions but more importantly reducing the error space which may serve as the template for errors to manifest themselves in the first place.

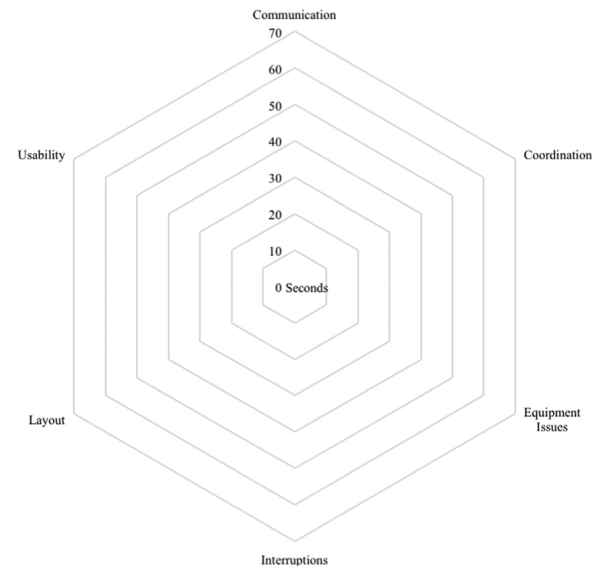

Fig. 1. The error space.

This investigation seeks to define the error space associated with the CVOR surgical team, the thoracic surgeon, scrub nurse, and physician assistant. The aim is to place surgical disruptions in a different light. Rather than viewing these disruptions as isolated events which may affect the surgical team, we represent them as an aggregated space which serves to disconnect the team from the task at hand. Furthermore, we will make the case that by understanding this error space, one can begin to target interventions that reduce the boundaries of this space and as a consequence reduce the opportunity for errors to develop.

2. Method

2.1. Data collection

Data was collected from the Cardiovascular Institute at Florida Hospital Orlando, a 2247-bed acute-care private, teaching medical facility. Over a four month period, 24 procedures, including valve repair/replacements and coronary artery bypass grafts (CABG), were observed during a total of 139.06 h of observation. Six different surgeons and their surgical teams were observed; however, it is important to note that the composition of each team varied case by case. Members of the surgical team were aware that researchers were observing and documenting disruptions to the workflow and knowledge of observation did not influence case assignment, team member assignment, or scheduling of the surgeries in any way. Because only observational behavior was documented for this study, Florida Hospital's Institutional Review Board determined this project except from further IRB review per federal regulations.

Doctoral-level human factors students from Embry-Riddle Aeronautical University observed each procedure from the time the patient was wheeled into the operating room until the procedure was completed and the patient was moved from the room. In an effort to remain as unobtrusive as possible, only two students observed any particular surgery at one time. Each observer collected workflow disruptions that impacted *two* cardiac team areas (either anesthesiology and perfusion or surgeon and circulating nurse). Therefore, in each surgery all four cardiac team areas were collected for analyses. This