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Use of a novel, modified fishbone diagram to analyze diagnostic errors

Abstract: Diagnostic errors comprise a critical subset of medical errors and often stem from errors in individual cognition. While traditional patient safety methods for dissecting medical errors focus on faulty systems, such methods are often less useful in cases of diagnostic error, and a broader cognitive framework is needed to ensure a comprehensive analysis of these complex events. The fishbone diagram is a widely utilized patient safety tool that helps to facilitate root cause analysis discussions. This tool was expanded by the authors to reflect the contributions of both systems and individual cognitive errors to diagnostic errors. We describe how two medical centers have applied this modified fishbone diagram to approach diagnostic errors in a way that better meets the patient safety and educational needs of their respective institutions.

Keywords: cognitive error; diagnostic error; fishbone diagram; root cause analysis; systems error.

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Introduction

The publication of the Institute of Medicine report "To Err is Human" in 1999 increased recognition of preventable medical errors and catalyzed the development of the patient safety movement [1]. Along with improvements in the safety of healthcare systems, there has emerged an increasing appreciation of the importance of diagnostic error in causing patient harm [2, 3]. Studies suggest an overall diagnostic error rate as high as 8%–15% with 17% of adverse events in hospitalized patients being attributable to diagnostic error [4, 5]. Yet despite the high prevalence and increasing profile of diagnostic errors, the best means of preventing and responding to them remains unknown [6].

One source of difficulty in addressing diagnostic error is the complexity of the underlying causative factors, with one study identifying an average of six contributory factors per error [7]. Further, there exist interdependencies and interactions between the imperfect human cognition and an imperfect work environment that complicate diagnostic error conversations [8, 9]. While physicians are becoming more comfortable discussing system factors that contribute to error, many have a limited understanding of the cognitive processes that underlie the diagnostic method and less comfort in acknowledging and learning from their own cognitive errors since they are by definition "personal" as opposed to being caused by "the system".

Thus, there is a need among both medical educators and patient safety experts for a structured approach to the analysis of diagnostic errors that accounts for their high degree of complexity. Root cause analysis (RCA) is one potential method of doing so. A recent study has described attempts to perform root cause analyses on diagnostic errors, citing that both systems factors and "team cognition" factors contribute to these errors [10]. However, the study does not comment on the widely acknowledged contributions of the individual cognitive processes to many diagnostic errors, as described by Croskerry [11]. Because diagnostic errors so frequently result from multiple factors, the approach to diagnostic error analysis should be comprehensive and include consideration of system-based, team-based and individual-bases cognitive factors, an approach Croskerry calls the "cognitive autopsy" [12].

Traditional tools used for RCA should thus be modified to accommodate the complexity of diagnostic error and include cognitive analysis. The fishbone diagram is one tool that shows potential for this. Initially described for use in quality assurance programs in the manufacturing industry, fishbone diagrams are now widely utilized as a patient safety tool to structure RCA of systems errors in hospitals and other healthcare settings [13, 14]. These diagrams facilitate the dissection of complex medical errors into discrete categories, and it was in the fishbone's visual display of inter-related categories that we saw the potential application to diagnostic error. Below, we describe how the traditional fishbone diagram has been adapted and successfully used at two institutions, Maine Medical Center, and the University of Pennsylvania, as a tool to understand and learn from diagnostic error.

Applications for patient safety

Within the patient safety program at Maine Medical Center, follow-up of diagnostic errors was frequently directed to the peer review process. Increased awareness of the multifactorial etiology of these errors led us to apply our existing root cause analysis process to such errors. However in doing so, we determined that the structure of the standard RCA was not likely to capture common contributors to diagnostic error such as affective bias and cognitive mistakes.

Using the standard fishbone diagram as a framework, a new RCA classification schema was constructed for diagnostic errors. Derived from components of the system proposed by Graber et al. as well as the Diagnostic Error Evaluation Research (DEER) taxonomy tool [7, 15], the new model served to encourage consideration of specific contributors to diagnostic error including cognitive processes, communication, clinician support and data gathering.

The modified fishbone diagram is now used as the underlying construct for all sentinel events with diagnostic error (Figure 1). This reframing of the review procedure and avoidance of the one-dimensional peer review process has resulted in a more comprehensive examination of these errors and increased institutional appreciation of the

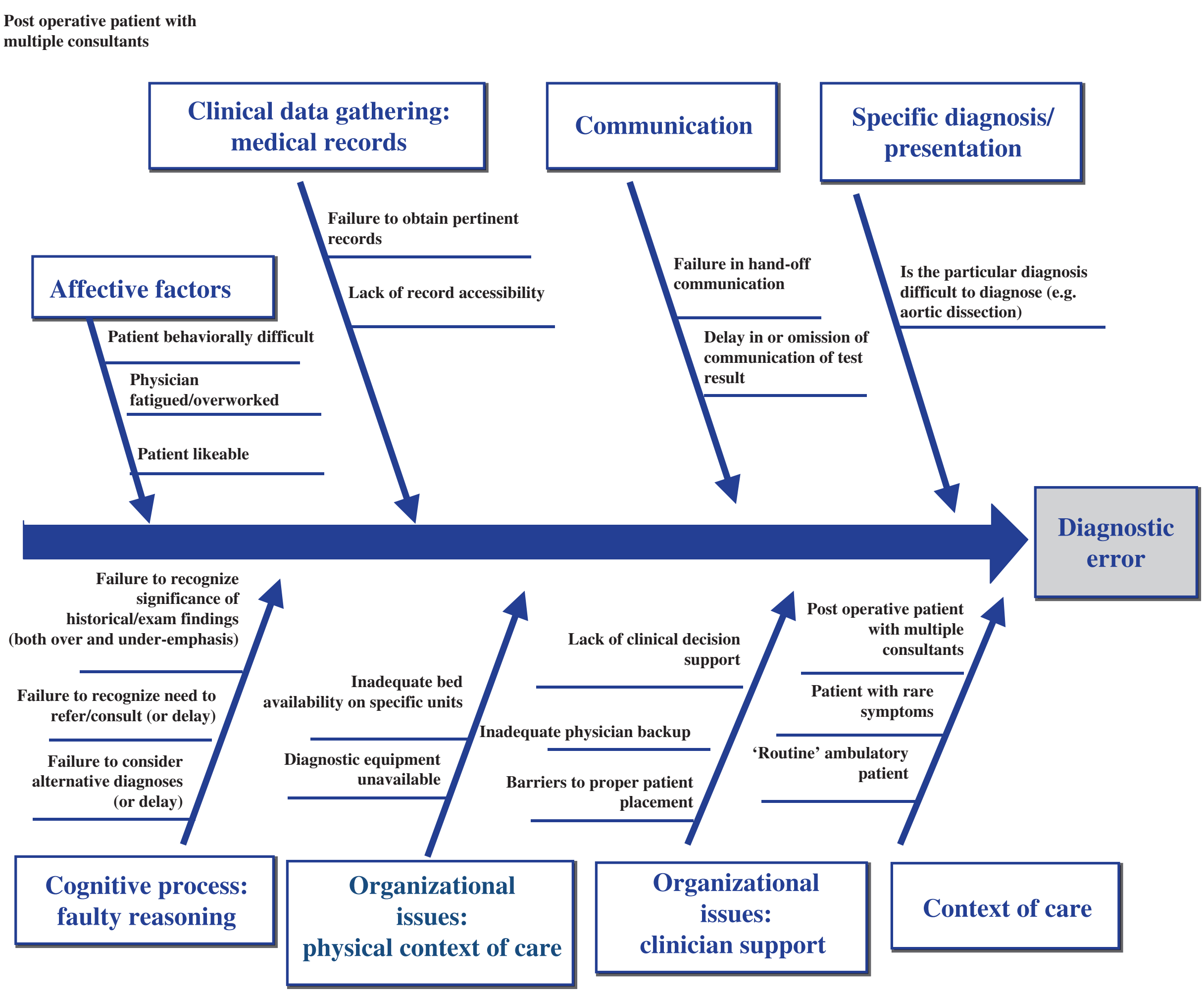

Figure 1 Diagnostic error fishbone framework in use at Maine Medical Center.

complexity involved. As a result, multiple contributors to diagnostic errors that otherwise may have been overlooked have been identified and specific interventions have been devised to prevent recurrence. An algorithm for the emergent evaluation of patients presenting with specific neurologic symptoms, an institutional consultation protocol and a proposed curriculum in the recognition of affective bias all resulted from this process. Furthermore, our overall impression is that physicians have shown a greater degree of interest and engagement in the RCA, perhaps because of the clinical nature of the discussions.

Applicatons for medical education

Within the internal medicine residency program at the University of Pennsylvania, we traditionally used the fishbone diagram during our patient safety conferences as a framework for organizing the multiple system factors that contributed to a preventable adverse event. Recognizing that systems and cognitive factors coexist and that both interact and contribute to many, if not most, cases of diagnostic error [7], we also added a cognitive component to the fishbone diagram. We believed that the use of this visual tool, and the systematic approach needed to construct it, would be helpful to residents as they learned how to analyze diagnostic error by identifying and differentiating cognitive from systems contributing factors. The modified fishbone diagram was introduced to our second year residents as one part of a longitudinal curriculum in cognitive bias and diagnostic error [16]. Residents worked in small groups with a faculty facilitator to identify the cognitive biases and system factors present in the case below to create a fishbone diagram adapted to the complex nature of a diagnostic error.

Our overall impression is that our residents found the adaptation of this familiar tool to be illustrative, practical and intuitive. Encouraged by positive informal feedback from our learners and faculty, we are also using the diagnostic error fishbone diagram to teach diagnostic and cognitive error concepts to medical students on their internal medicine clerkship. Here we offer a case example of how the modified fishbone diagram can be created and applied (Figure 2).

Case

A 47-year-old male with type 1 diabetes mellitus presented to the Emergency Department (ED) with fatigue, abdominal pain and vomiting. Past medical history included diabetes, and his only medication was insulin. On physical exam, he was thin and in pain. His blood pressure was 96/58, pulse 70, temperature 98, with normal oxygen saturation. His abdomen was soft but diffusely tender. Labs were notable for glucose of 197 mg/dL, creatinine 1.2 mg/dL, potassium of 5.8 mEq/L and an anion gap of 22. Abdominal computed tomography scan showed no pathology. The patient was diagnosed with viral gastroenteritis and diabetic ketoacidosis from insulin non-adherence. Insulin and intravenous fluids were begun. Follow-up labs showed a potassium of 5.3 mEq/L and a normal anion gap. The insulin drip was stopped and the ED physician gave report to the admitting night resident. The resident reviewed the chart and discovered that the patient had been admitted four times in the past year with similar symptoms and had delayed gastric emptying on a prior gastric emptying study.

The next morning the on-call team visited briefly with the patient who was waiting for a ward bed. The discussion was truncated because of other new admissions, but the team agreed to initiate metaclopramide and hold narcotics. The intern later received multiple pages because the patient was requesting pain medicine. Stuck on the floor in rounds and on the advice of his resident (*"His CT's negative; he's probably a frequent flyer looking for drugs. Doesn't he know that narcotics will worsen his gastroparesis?"*), the intern suggested over the phone that acetaminophen be given. After several requests for narcotic pain medication were denied, the patient left the ED against medical advice.

Two days later, the patient was readmitted with lightheadedness and fatigue. He remained hypotensive and hyperkalemic with a potassium of 5.9 mEq/L. A detailed history clarified that the patient's most concerning symptom was fatigue, which had led to loss of his job and insurance 9 months' previously. Further review of past records showed the potassium level was often in the mid-5 range, and 4 months ago, the patient had had an equivocal serum cortisol level drawn in the hospital. He failed to follow up with an endocrinologist because when he called to make an appointment, he was told that he had to secure insurance through medical assistance before he could be scheduled. The physical exam on rounds discovered slightly darkened skin, which the patient noted over the last few months. Cosyntropin stimulation test confirmed a diagnosis of adrenal insufficiency.

Conclusions

Although the degree to which diagnostic errors can be prevented is controversial and currently unknown, this

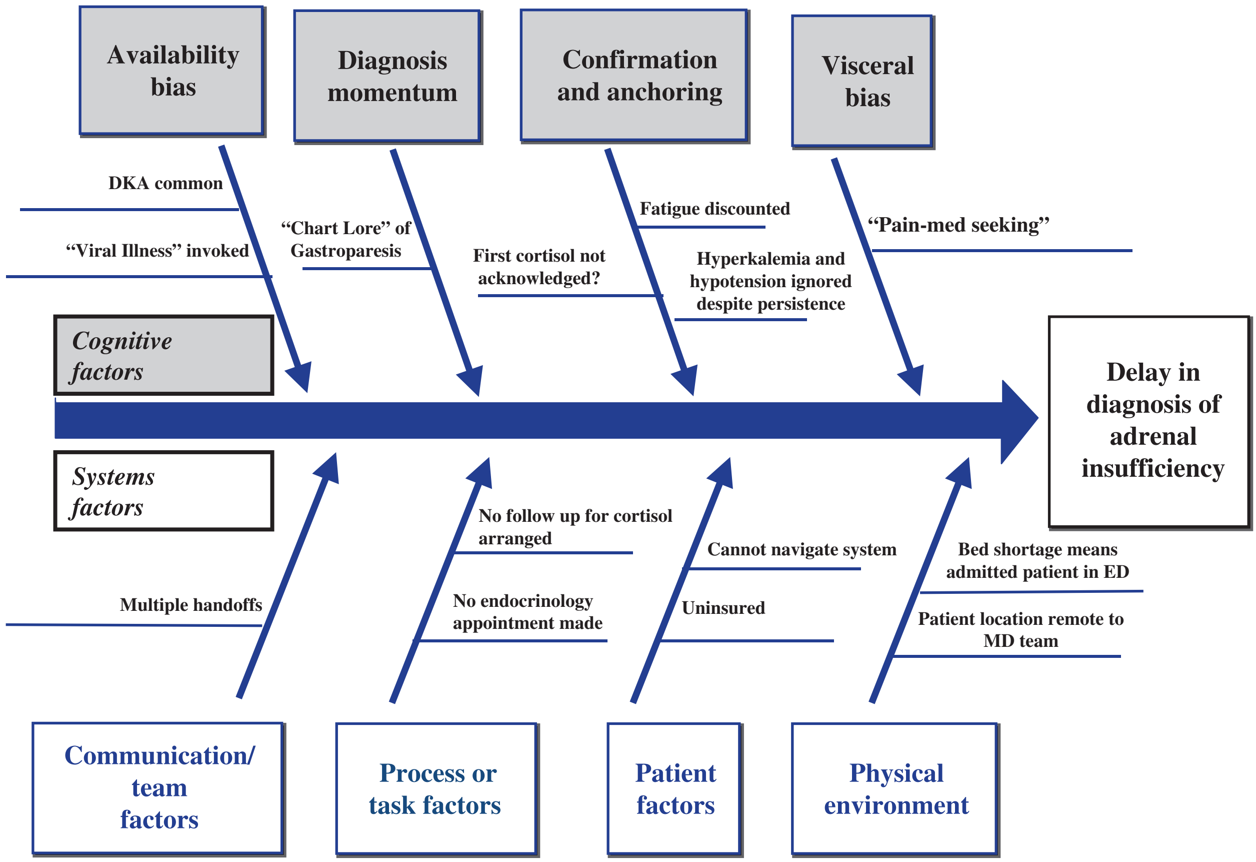

Figure 2 Diagnostic error fishbone highlighting cognitive versus systems contributing factors: a case of a delayed diagnosis of adrenal insufficiency.

uncertainty should not prevent attempts to improve diagnostic reliability. Modifying the fishbone diagram for diagnostic error analysis and education is one practical attempt that is advantaged by its concreteness and familiarity among patient safety experts and educators. We provide anecdotal reports of the utility of this approach within two centers, and hope that others will use and build upon this tool in an effort to learn and improve from their local diagnostic errors. We note that the traditional systems-focused fishbone diagram and root cause analysis framework are limited by a lack of evidence linking it to better outcomes [17], but these widely utilized tools remain practical ways to identify and address safety hazards in healthcare. We are pleased to offer this modified fishbone diagram as a tool for a more comprehensive approach to analyzing and teaching about the complexities of diagnostic errors.

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Conflict of interest statement

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References

1. Kohn LT, Corrigan J, Donaldson MS. To err is human: building a safer health system. Washington, DC: National Academy Press, 2000.
2. Wachter RM. Patient safety at ten: unmistakable progress, troubling gaps. Health Aff (Millwood) 2010;29:165–73.
3. Newman-Toker DE, Pronovost PJ. Diagnostic errors – the next frontier for patient safety. J Am Med Assoc 2009;301:1060–2.
4. Shojania KG, Burton EC, McDonald KM, Goldman L. Changes in rates of autopsy-detected diagnostic errors over time: a systematic review. J Am Med Assoc 2003;289:2849–56.
5. Leape LL, Brennan TA, Laird N, Lawthers AG, Localio AR, Barnes BA, et al. The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. N Engl J Med 1991;324:377–84.
6. Graber M, Gordon R, Franklin N. Reducing diagnostic errors in medicine: what's the goal? Acad Med 2002;77:981–92.
7. Graber ML, Franklin N, Gordon R. Diagnostic error in internal medicine. Arch Intern Med 2005;165:1493–9.
8. Schiff GD, Hasan O, Kim S, Abrams R, Cosby K, Lambert BL, et al. Diagnostic error in medicine: analysis of 583 physician-reported errors. Arch Intern Med 2009;169:1881–7.
9. Henriksen K, Brady J. The pursuit of better diagnostic performance: a human factors perspective. Br Med J Qual Saf 2013;22(Suppl 2):ii1–5.
10. Giardina TD, King BJ, Ignaczak AP, Paull DE, Hoeksema L, Mills PD, et al. Root cause analysis reports help identify common factors in delayed diagnosis and treatment of outpatients. Health Aff (Millwood) 2013;32:1368–75.
11. Croskerry P. The importance of cognitive errors in diagnosis and strategies to minimize them. Acad Med 2003;78:775–80.
12. Croskerry P. Diagnostic failure: a cognitive and affective approach and methodology. In: Henriksen K, Battles JB, Marks ES, Lewin DI, editors. Advances in patient safety: from research to implementation (Volume 2: Concepts and methodology). Rockville (MD): Agency for Healthcare Research and Quality (US), 2005.
13. The Joint Commission Sentinel Event Policy and Procedures for Hospitals. [cited 2014 February 8]; Available from: http://www.jointcommission.org/assets/1/6/CAMH_2012_Update2_24_SE.pdf.
14. Bagian JP, Gosbee J, Lee CZ, Williams L, McKnight SD, Mannos DM. The Veterans Affairs root cause analysis system in action. Jt Comm J Qual Improv 2002;28:531–45.
15. Schiff GD, Kim S, Abrams R, Cosby K, Lambert B, Elstein AS, et al. Diagnosing diagnosis errors: lessons from a multi-institutional collaborative project and methodology. In: Henriksen K, Battles JB, Marks ES, Lewin DI, editors. Advances in patient safety: from research to implementation (Volume 2: Concepts and methodology). Rockville (MD): Agency for Healthcare Research and Quality (US), 2005.
16. Reilly JB, Ogdie AR, Von Feldt JM, Myers JS. Teaching about how doctors think: a longitudinal curriculum in cognitive bias and diagnostic error for residents. Br Med J Qual Saf 2013;22:1044–50.
17. Wu AW, Lipshutz AK, Pronovost PJ. Effectiveness and efficiency of root cause analysis in medicine. J Am Med Assoc 2008;299:685–7.