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Metrics-driven successful strategy by emergency and radiology driven task force to mitigate global CT contrast media shortage in a safety net hospital

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ABSTRACT

Iodinated contrast media (ICM) shortages and secondary supply chain problems due to Coronavirus Disease lockdowns in China significantly impacted radiology operations nationwide. The lack of ICM necessitated operational workflow changes designed to ration contrast use, particularly in the hospital setting. In this manuscript, we share our strategic methods with advanced process/outcome metrics to monitor the effectiveness of our strategy under a coordinated multidisciplinary team effort. Alternate studies such as substituting magnetic resonance angiography for computed tomographic angiography for emergency department patients were studied to measure the suitability of these examinations for specific diagnoses. This article presents readers with a comprehensive crisis management strategy deployed at our institution, emphasizing various options with a limited ICM supply, and minimizing the impact on clinical care.

Keywords: Contrast shortage, Iohexol, American college of radiology strategies, Iodinated computed tomography contrast, Coronavirus disease

INTRODUCTION

Imaging is pivotal in contemporary healthcare, with diagnostic and therapeutic procedures commonly utilized. Iodinated contrast media (ICM) is most widely used in computed tomography (CT), CT angiography (CTA), conventional angiography, fluoroscopy-guided procedures, and venography. Around 40% of CT examinations use ICM for visualizing and diagnosing various pathophysiological conditions.[1] The ICM shortage affected multiple service lines such as cardiology, neurology, vascular surgery, gastroenterology, and urology.[2-4] Both inpatient and outpatient imaging services were impacted.

Iohexol is a non-ionic ICM employed in imaging techniques through intra-arterial, intravenous, enteric, or genitourinary administration. The General Electric (GE) Healthcare production plant, located in Shanghai, China, is the major supplier (>50%) of iohexol (Omnipaque) ICM to the United States. However, the coronavirus disease (COVID-19) outbreak in April 2022 resulted in a lockdown in Shanghai, China, which significantly impacted the production of ICM and severely constrained the amount of available contrast. GE Healthcare notified its customers to expect an 80% order fulfillment shortage that would last until late June 2022.[5-8] By May 21, 2022, GE increased production at the Shanghai plant by following COVID protocols and increased the output from 0% to 60%, and the production levels are expected to continue to rise.[9]

OVERARCHING STRATEGY AND BACKGROUND ANALYSIS

The American College of Radiology (ACR) Committee on Drugs and Contrast Media recommended several strategies to encourage providers to incorporate sensible clinical judgment in delivering contrast to patients [Tables 1 and 2].[10] Our multidisciplinary involved identifying key service lines affected by the ICM shortage and developing mitigation strategies specifically tailored for each subspecialty [Figure 1]. Engagement with key stakeholders at the beginning of a crisis is imperative to developing an effective strategy.[11] At our institution, the radiology team served as the primary decision-maker on decreasing contrast usage while offering alternative imaging modalities when applicable. The pharmacy department took ownership of centralized inventory management. Interventional radiology, cardiology, and surgical specialty need contrast consumption were similar.[12] Hence, the mitigation strategies were aligned with the institutional disaster management team, and information technology (IT) played vital roles in the enterprise's communications.[13] Last but not least, we built at least 2 weeks of contrast reserves to provide optimal care for emergency department (ED) patients in case the shortage became protracted and while other strategies to acquire contrast while decreasing waste was put in place.[14-16]

The task force designed a heat map to identify, prioritize, and assess the feasibility of the action steps. Impact scoring, as shown in [Figure 1], further aided the task force in focusing on high-value action items. Our systematic

Table 1: Mitigation strategies by ACR.

Mitigation strategies by ACR
Use alternative imaging studies such as non-contrast CT, contrast/non-contrast MRI, and contrast/non-contrast ultrasound
Use of nuclear medicine techniques when feasible
Look for alternate brands of contrast or a contrast from different vendors
Repackage large volume vials into multiple small vials to reduce the contrast wastage
Minimize the individual doses by considering body weight or scanner kilovoltage or employing a dual-energy CT scanner in clinical practice to obtain the optimal image quality
Reserve the higher concentration for vital studies such as angiographic and multiphasic studies
Use of alternative contrast agents such as diatrizoate, gastrografin, and barium-based products for gastrointestinal and genitourinary imaging

MRI: Magnetic resonance imaging, CT: Computed tomography, ACR: American College of Radiology

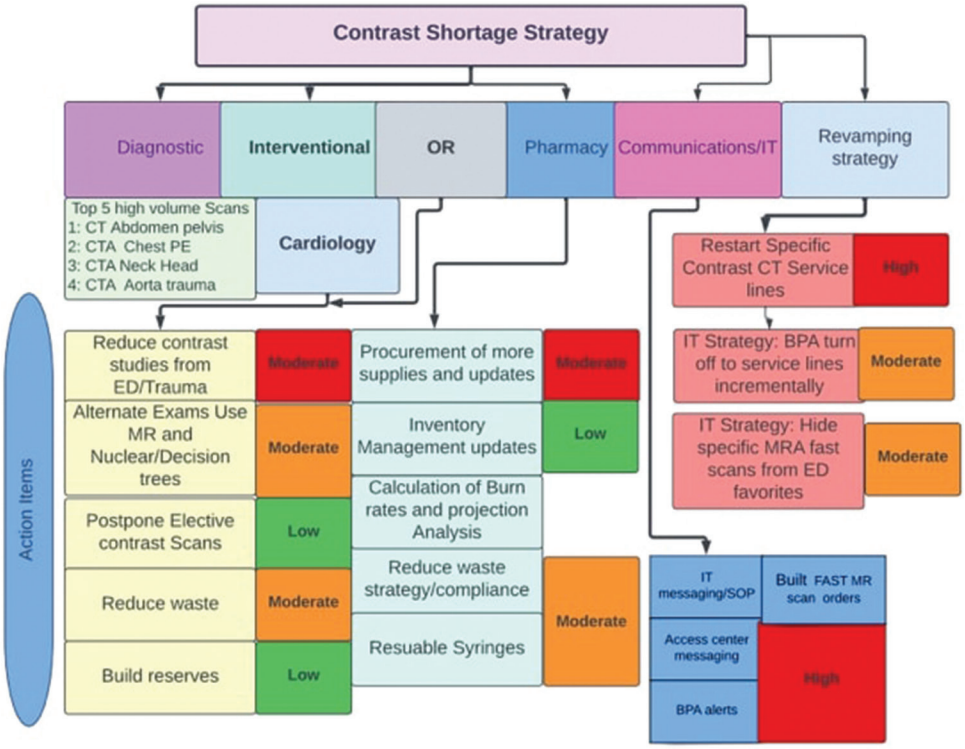

Figure 1: Strategies and multifaceted mitigation steps at UF Health to address the computed tomography contrast crisis. Mechanism to prioritize key operation strategic action steps and their impact on key stakeholders. OR: Operation room.

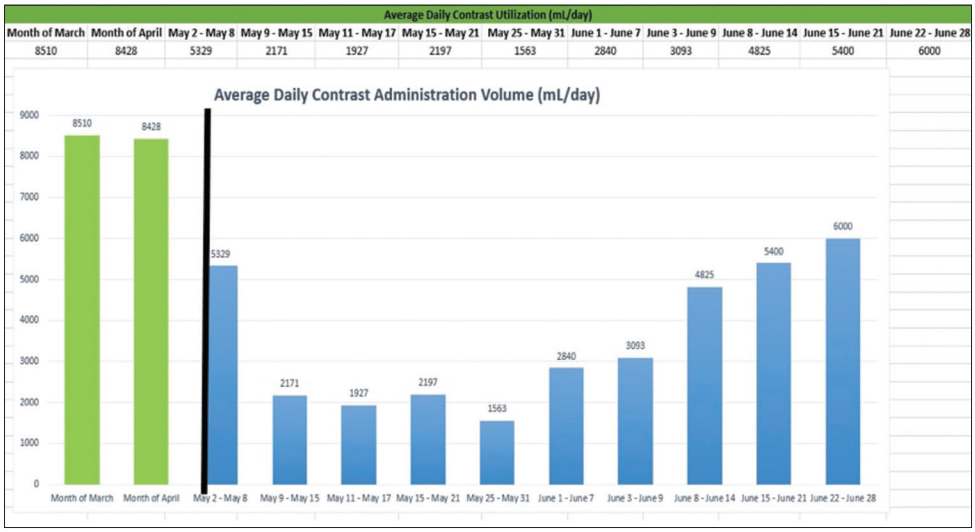

Figure 2: Contrast Volume consumption tracking in ml in March, April, May, and June of 2022. Notice the relaxation of mitigation measures (arrow) in the 1st week of June.

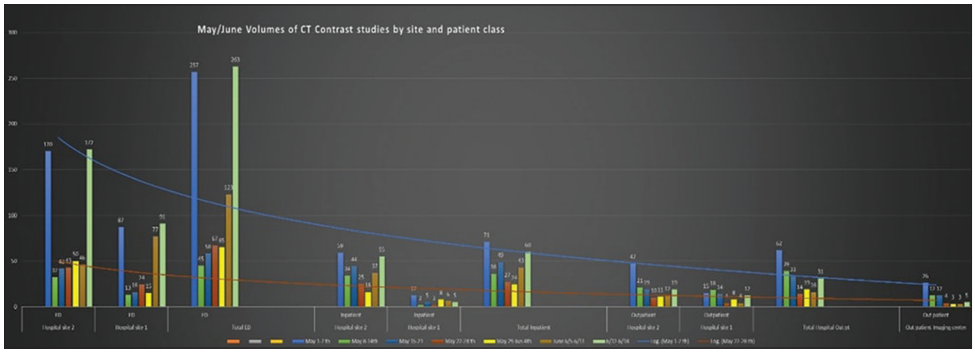

Figure 3: Post-contrast computed tomography volume studies tracking across locations (hospitals/outpatient imaging centers) comparing weeks of May and mid-June 2022. Notice the infliction point in the 1st week of June after the relaxation of mitigation measures.

Table 2: Metrics monitoring mitigation strategies.

Type of Metric	Process	Outcome
Contrast volume usage	Yes	No
Number of post-contrast CT	Yes	No
Miss rate among non-contrast CT abdomen pelvis	No	Yes
Miss rate among negative MRA pulmonary embolism	No	Yes

CT: Computed tomography

approach helped us design and measure critical short- and long-term strategies and addresses effective communications to decrease unnecessary contrast usage and waste until the production shortage is resolved.[15]

The five most contrast intensive CT examinations were identified by patient class (Emergency/Inpatient and Outpatient) and based on historical analysis in our institution. This provided the task force with the current contrast usage rate in terms of the volume of contrast (mL) used daily relative to the remaining inventory. This allowed us to know how many days our supplies would enable us to operate. This further provided us to aggressively reduce the overall daily utilization across the enterprise by around 60–80% [Figure 2].[5,14]

Key strategic initiatives

They were identifying strategies that decreased contrast usage and addressing the high-impact factors initially was the key to navigate the ICM production shortage successfully. Our steps mirrored the strategic actions taken by multiple other institutions and are consistent with ACR recommendations with overarching goals of extending contrast supply run rate and reducing waste.[10,17]

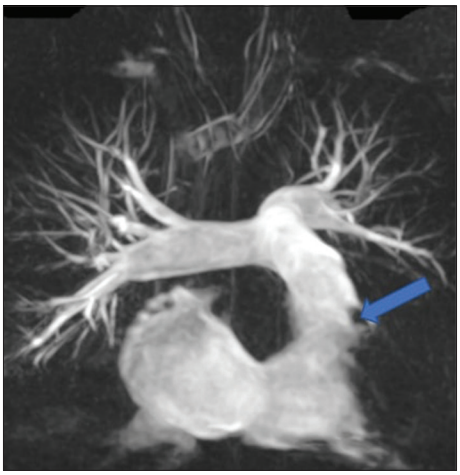

Figure 4: A 42-year-old male with a history of recent travel presented with acute shortness of breath and chest pain diagnosed with pulmonary embolism. Imaging obtained through fast magnetic resonance imaging protocol demonstrates pulmonary embolism (arrow).

Figure 5: A 55-year-old female with a history of chronic tobacco abuse presented with abdominal pain secondary to aortic aneurysm. Illustration demonstrating the aortogram (arrow) and embolization with CO_2 as a contrast agent.

REDUCING CONTRAST CT STUDIES STRATEGY

Our institution's ED and inpatient categories of patients consume approximately 80% of daily contrast volume. Therefore, our efforts focused on these patient populations. Identifying the clinical indications for ICM required input from ED, trauma, and inpatient services to develop alternative imaging studies.[11,14] In our institution, non-contrast CT examinations were quickly adapted substituted when applicable, resulting in a significant drop in contrast

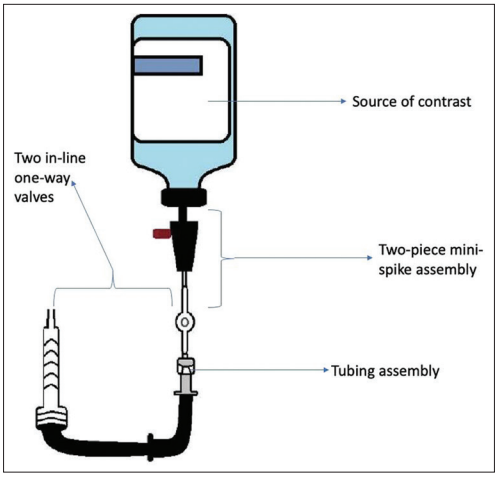

Figure 6: Squeeze contrast controller tubing system: A two-piece aseptic 1-time tubing-use system that aids in using a single multiuse bottle within 6 h.

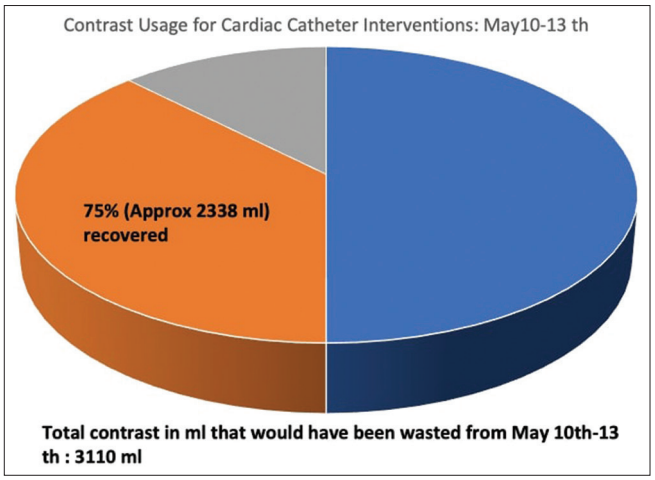

Figure 7: Pie chart demonstrating approximately 75% of contrast recovery due to new tubing system on analysis of a 4-day utilization from the cardiology cath laboratories.

consumption [Figure 3]. Similarly, there was an increase in available contrast from GE in mid-June as the production at the Shanghai plant expanded.

Delaying elective or outpatient contrast-enhanced CT imaging (CECT) was recommended for ordering providers by 1 month or 3 months depending on the necessity of ICM, a similar strategy reported by Grist *et al*.[8,18]

ALTERNATIVE CONTRAST OR STUDIES STRATEGY

Alternative imaging modalities

CECT can be redirected to alternate imaging techniques such as magnetic resonance imaging (MRI) and

ultrasound.[19] For instance, magnetic resonance angiography (MRA) can be substituted for CTA in patients with suspected aortic dissection or pulmonary embolism with stable hemodynamics. We created ultra-fast MRI and MRA protocols and orders, which were incorporated into EPIC ordering lists [Figure 4]. These fast MR protocols were abbreviated (scan times 20 min or less), and additional slots were built into the schedules to increase their availability. We monitored the fast MR scan volume and changed MRI technologist staffing appropriately. Similar strategies were employed for nuclear medicine for ventilation-perfusion (V/Q) scans and tagged red blood cell scans.

Intravascular ultrasound assesses the vascular anatomy with the advantage of decreased procedural time and radiation exposure. It has been employed by cardiology for coronary and peripheral arterial work, reducing consumption usage.

Alternative contrast agents

Alternative agents can be employed for vascular and non-vascular diagnostic imaging studies and interventions. For vascular applications in interventional radiology and cardiology, contrast volume usage was achieved by diluting ICM for each case and reducing waste using a multi-valve tubing system which allowed contrast vials to be used for multiple patients, thereby increasing available supply. Carbon dioxide (CO_2) angiography is successful in patients in whom ICM is contraindicated such as in severe renal disease of ICM allergies [Figure 5]).[8] Gadolinium (Gd) can be used even in

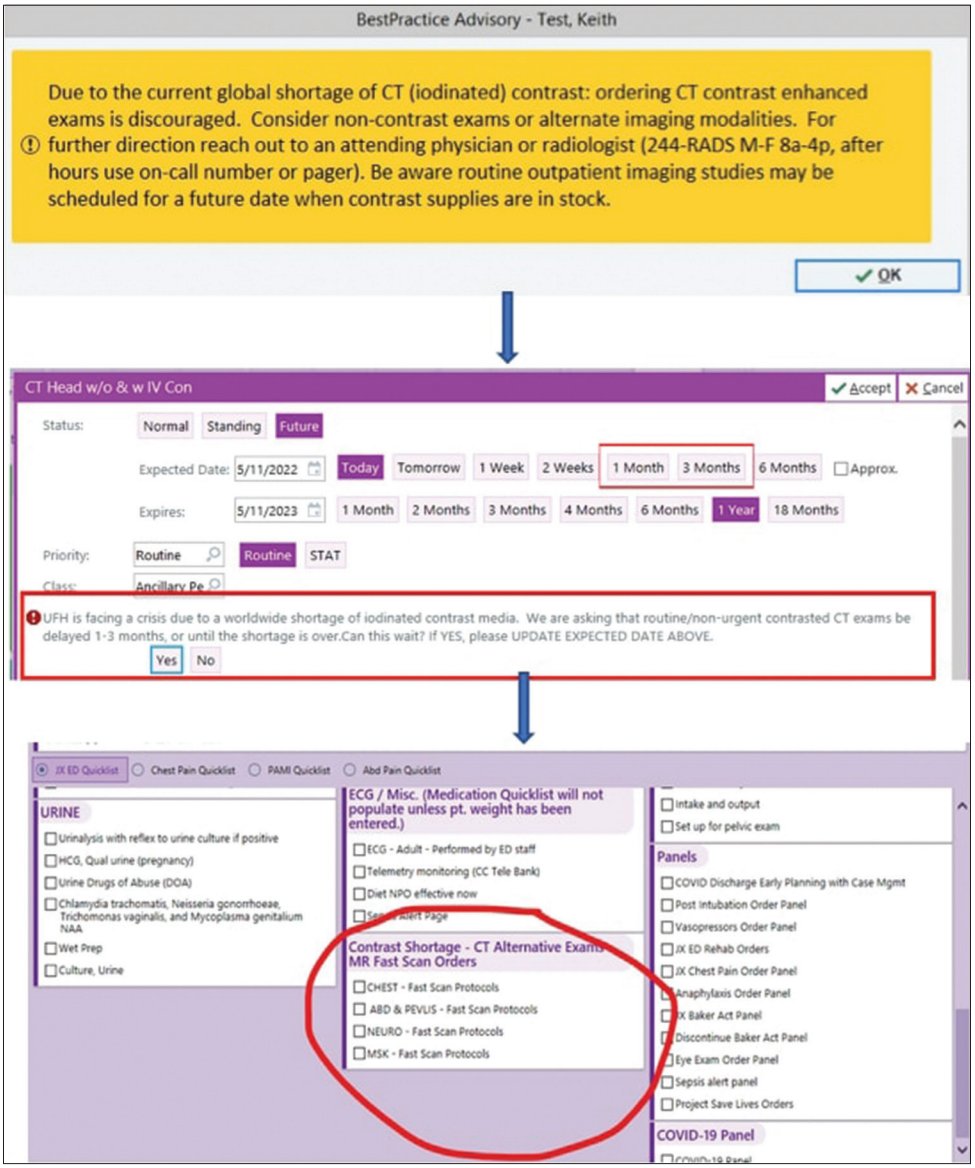

Figure 8: IT and communications strategy.

patients with renal insufficiency at a dose <0.3–0.4 mmoL/kg body weight.[20] At our institution, maximum dose Gd and CO_2 angiography were widely adopted.

Gastrografin (Diatrizoate meglumine, Bracco Diagnostic Inc.) was immediately adapted for oral and rectal administration as a viable alternative for ICM. Cystografin was widely used to access genitourinary tract procedures such as nephrectomies and exchanges.

CONTRAST WASTE MITIGATION STRATEGY

Reducing contrast waste is as critical as reducing consumption during this crisis. A multi-prong approach to reduce wastage of contrast varied from reduced volume per study to innovative tubing and repacking in smaller aliquots. ACR recommends repackaging single-use vials into multiple-use ones to prevent contrast wastage.[21] Our pharmacy assisted in repackaging smaller aliquots following the International Organization for Standardization class 5 rooms regulation;[22] these aliquots were primarily used for joint injection and surgical procedures.

A more effective protocol adopted in our institution was the innovative tubing system (squeeze contrast control system) [Figure 6]. This aseptic tubing system was widely used in cardiology cath laboratories as their inventory contained larger volume contrast bottles (200 mL). As a result, we could use one bottle for three cardiac patients, reducing wastage of contrast by 75% [Figure 7]. We are confident that these savings will translate to minimizing costs moving forward.[23]

IT AND COMMUNICATIONS STRATEGY

A good communications strategy is essential for enterprise-level success. In our institution, with the help of a disaster management team and senior leadership system, comprehensive communication messaging was done at the beginning of the crisis. Further, a unified message was reinforced to reduce the use of contrast CT with IT tools. Best Practice Advisory tools were deployed [Figure 8] at the point of order entry and final sign-off of the CT orders. This dual messaging methodology ensured that the ordering and sign-off providers were informed of the crisis and suggested imaging alternatives while ordering CT examinations. Messaging to patients was also provided using the scheduling access phone tree, ensuring that patients were informed of the reason for their examination delay or a change.

REVAMPING STRATEGY

The decision to slowly revamp contrast CT examinations were based on daily modeling of contrast utilization, run rate (days in hand), and inventory procurement. Our infliction point was in the 1st week of June when the task force decided to slowly ease the restrictions in ED and inpatients [Figure 3]. At the time of full strategic implementation, we had established a 2 weeks ICM reserve, 60 days inventory level at a daily consumption rate of 3000 mL/day. In the 2nd week of June, the best practice alerts were removed to encourage providers to resume standard ordering patterns of contrast studies.[11,12,24]

CONCLUSION

The global shortage of ICM has led to disruption in imaging operations, and the institutions are undertaking mitigation strategies without compromising on clinical excellence. We achieved an 80% reduction in contrast usage by adopting a comprehensive approach driven by process and quality metrics. We continue to monitor our utilization and have adapted waste reduction strategies to reduce costs.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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