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Case report

The use of dye to detect sites of hemorrhage and leak in postmortem cases

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A B S T R A C T

This study introduces a novel, cost-effective, and rapid method for identifying hemorrhage or leakage sites following postoperative deaths, a critical aspect in the context of medical malpractice litigation. The technique employs diluted ink as an injectable dye, providing an alternative to postmortem contrast imaging. The utility of this method was demonstrated through a series of three cases. In the first case, the technique successfully detected leaks within vascular structures. The second case revealed a leakage in the cystic duct, while in the third case, the method was instrumental in identifying a leak in a hollow organ situated below the gastro-esophageal junction. Given its demonstrated efficacy, this technique has been incorporated into routine practice by the forensic pathologist in the medicolegal directorate in Baghdad, Iraq.

1. Introduction

During postmortem examinations, it is crucial to precisely identify hemorrhage or leakage sites following postoperative mortality, especially in the context of medical malpractice litigation. This responsibility not only reveals the complications experienced by patients but also provides vital evidence of medical culpability.[1] The complexity of this task is amplified during autopsies, particularly when damage to small arteries goes undetected by the unaided eye of the pathologist. Additionally, extensive hemorrhage, blood clots, adhesions, and inflammation at the autopsy site, especially in cases involving prolonged survival after surgical complications, present a significant challenge. These conditions make delicate manipulation of adherent and/or inflamed organs prone to inadvertent tearing and artifact-induced injuries, leading to uncertainties and disputes regarding autopsy artifacts in the investigation of postoperative mortalities.

The utilization of various substances for arterial injection during postmortem examinations has been previously documented by researchers for diverse purposes. Notably, the injection of a silicone compound that rapidly solidifies postmortem was delineated by a cohort of scholars for the purpose of anatomically studying the cerebrovascular system in cadavers. Importantly, this method demonstrated minimal interference with standard autopsy observations. Furthermore, this approach facilitated anatomical investigations of specimens obtained from cadavers admitted to forensic facilities for brief durations.[2,3]

A recent study focused on understanding arterial circulation to enhance the management and diagnosis of specific anatomical diseases. The method used vinylpolysiloxane silicone to block the internal carotid arteries, enabling the creation of a detailed representation of their internal structure. This technique has been utilized in traditional autopsies and has contributed to more accurate diagnoses of fatal conditions.[4]

Various postmortem radio-imaging techniques, including computed tomography (CT) and magnetic resonance imaging (MRI), have been incorporated into forensic investigations, reflecting the increasing sophistication of postmortem procedures. These techniques offer numerous advantages, including rapid data acquisition and the ability for acquired data to be re-evaluated at any point and utilized in a judicial context.[5] Within this framework, the significance of postmortem angiography is amplified due to its ability to swiftly assess organ-specific vascular patterns, vascular changes under pathological and physiological conditions, as well as tissue alterations resulting from artificial and non-natural causes.[6,7]

In this article, we introduce a new method that utilizes blue ink as a dye to identify areas of bleeding and leakage. This technique has become a standard procedure during autopsies conducted at the Medical Legal Directorate (MLD). We demonstrate its use through three autopsy cases. These cases were referred to the MLD for forensic autopsies due to allegations of medical malpractice resulting in post-operative deaths.

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2. Material and methods

This research was carried out at the Medical Legal Directorate (MLD) based in Baghdad, Iraq. The MLD granted ethical approval for this study in January 2021. Informed consent was obtained from the next-of-kin for each of the deceased individuals featured in this paper.

The autopsies were conducted utilizing a midline incision; two were performed in situ, while the third was performed en-masse. The ink dilution in our routine work and the three cases in this study, we found that adding just a few drops of ink to 400 cc of tap water worked well. This method gave us the right ink concentration: it wasn't too dark, and it wasn't too light. This balance made it easy for us to see what we needed to without affecting any follow-up analysis. The preparation of freshly diluted ink dye is recommended, as diluted ink tends to form a suspension over time and the ink begins to separate from the water.

Upon evaluation, we've determined that the utilization of both straight and curved artery forceps for the clamping of proximal and distal artery branches proves more effective than the application of sutures. This is particularly relevant when fast clamping and release of a vessel are required. Our research indicated that the use of sutures is time-intensive and carries a substantial risk of arterial injury, given the fragile nature of arteries and their propensity to tear in post-mortem conditions.

Comprehensive documentation in the form of colored still photographs and videos was undertaken for all cases, with the intent of furnishing evidentiary support in the event of challenges to the forensic reports, whether in a legal setting or by a panel of specialized medical professionals engaged in the review of post-operative mortality cases.

Case 1. Medical and surgical history: A 39-year-old gravida, with a history of five pregnancies, three successful deliveries, and one abortion (Gravida 5, Parity 3, Abortion 1), was admitted to the hospital for an urgent caesarean section due to obstructive labor and antepartum hemorrhage. Her medical record showed an unremarkable medical history, and her current pregnancy was proceeding uneventfully with regular antenatal check-ups. Post the delivery of the fetus, the patient developed pelvic hemorrhage of unidentified origin, resulting in intra-operative hypovolemic shock. Subsequently, a total hysterectomy was performed, and a drainage tube was inserted in the pelvic region before the closure of the incision in layers. The patient was transfused with four units of whole blood, fresh frozen plasma, and packed platelets. Nevertheless, the drainage tube continued to discharge blood over the next 9 h, leading to a progressive deterioration in the patient's circulatory status, ultimately culminating in her demise despite the administration of requisite interventions to manage the hypovolemic shock.

The autopsy: The deceased individual was referred to the Medical Legal Directorate (MLD) in response to a complaint of medical malpractice, leading to the necessity of a forensic autopsy. Upon examination during the autopsy, an accumulation of approximately 2.8–3 L of blood in the peritoneum was noted. To accurately measure the blood volume, an electrical suction device was utilized to drain the peritoneal cavity. A precise and cautious dissection technique was employed to trace the internal arteries stemming from the umbilical arteries, with the aim of avoiding inadvertent injuries. The anterior trunks of the internal iliac arteries were clamped near their origins using artery forceps to prevent retrograde flow. In order to pinpoint the exact location of leakage, a diluted ink solution was injected into the anterior trunk of the internal iliac artery using a 5 cc syringe. This procedure successfully identified a site of leakage that was not visible to the naked eye (Fig. 1). No incisions or sharp cuts were evident in the left internal iliac artery. Documentation of the findings at the site of leakage included still photographs and videos.

Conclusion: The postmortem examination led to the conclusion that the source of bleeding was an iatrogenic vascular injury caused by the application of cautery.

Case 2. Medical and surgical history: A 68-year-old female patient

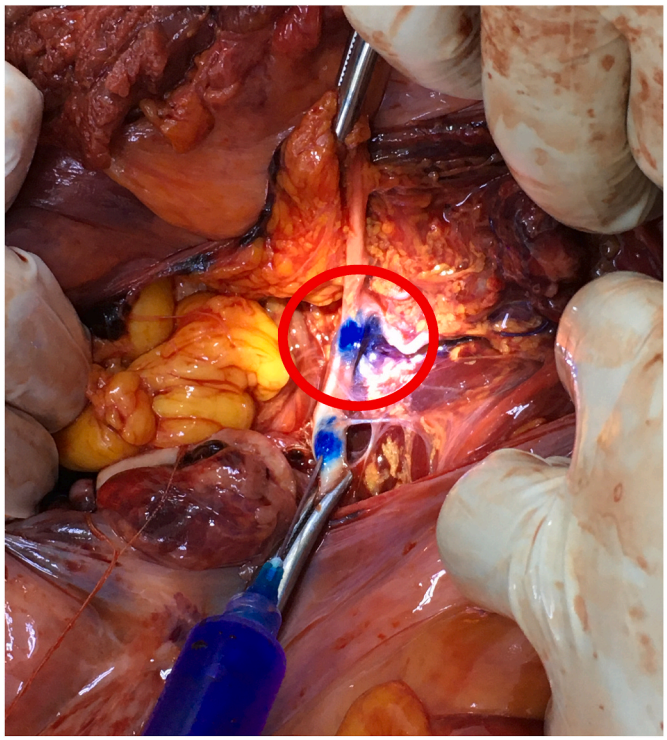

Fig. 1. The anterior trunk of the left internal iliac artery was clamped by an artery forceps proximally and diluted ink is being injected. A leak of dye was noticed distally near the origin of the left uterine artery (red circle). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

with a pre-existing condition of right hypochondriac pain recently underwent a laparoscopic cholecystectomy. The procedure was completed without incident; however, the patient began to exhibit various symptoms the day following the operation. These symptoms included pyrexia, dyspnea, abdominal distention, diarrhea, and emesis.

Twelve days subsequent to the initial surgery, a laparotomy was performed, which revealed peritonitis. To manage this medical condition, a feeding jejunostomy was performed, along with the placement of a stent within the common hepatic duct and the installation of a drain in the peritoneal cavity.

Of significance is the continuous discharge of a dark yellow-greenish fluid from the peritoneal drain over the following fortnight.

The patient's health took a turn for the worse and she passed away about four weeks after the second surgery. Because of a claim of medical malpractice, her case was then passed on to the Medical Legal Directorate (MLD).

The autopsy: A postmortem examination was conducted, revealing evidence of bile staining present within the intraperitoneal organs. Additionally, there was an accumulation of pus and bile in the right hypochondrium, specifically in the area posterior to the liver. Severe peritonitis was observed, coupled with omental fat necrosis and adhesions of the intraperitoneal organs.

In an attempt to further elucidate the cause, a diluted ink injection was administered into the common hepatic duct, which unveiled a leak originating from the stump of the cystic duct, as showed in Fig. 2. The postmortem examination culminated upon the procurement of samples for histopathological analysis from the affected organs.

Conclusion: The final diagnosis was determined as bile peritonitis, a condition consequent to a bile leak following the cholecystectomy procedure.

Case 3. Medical and surgical history: A 36-year-old female patient was subjected to a laparoscopic sleeve gastrectomy procedure. Postoperative

Fig. 2. Injection of ink into the common hepatic duct showed leak from the cystic duct stump (red circle). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

complications ensued seven days post-surgery, characterized by emesis, abdominal distention, and dyspnea. A laparotomy was subsequently performed, during which a feeding jejunostomy was established and drains were inserted into the peritoneal cavity.

Despite a temporary improvement in her symptoms for a duration of two days, the peritoneal drains continued to discharge dark-colored fluid. The patient's condition progressively deteriorated over the ensuing eight days, culminating in her death.

The autopsy: Following her death, a medical malpractice claim was filed, and a postmortem examination was conducted. The autopsy revealed severe peritonitis accompanied by bile staining and adhesions of the small intestine, as shown in Fig. 3. To avoid any disruption to the inflamed abdominal organs, an en-masse technique was employed, and ink dye was injected into the esophagus to identify the site of the leak between the stomach and the liver. The presence of adhesions facilitated the immediate identification of the site, as manipulating the organs could have resulted in tearing artifacts, as shown in Fig. 4. Subsequent dissection aimed to isolate the esophagus with the stomach from the surrounding block, allowing for visualization of the precise location of the leak (Fig. 5).

Conclusion: The postmortem examination concluded that peritonitis resulted from a leak originating from the sleeve gastrectomy site, situated just below the gastro-esophageal junction. Adequate photography and tissue sampling were performed for histopathological analysis.

3. Discussion

Bleeding and hemorrhage incidents resulting in fatality pose considerable complexities for forensic pathologists, specifically when tasked with determining the origin of the bleed. Furthermore, it is incumbent upon forensic investigation to establish whether the cause of the bleeding is linked to trauma, an underlying medical condition, or a combination of both.

After a thorough series of tests and improvements, we successfully used common stamp pad ink to locate the leakage sites in blood vessels

Fig. 3. Severe peritonitis with pus collection and bile staining.

Fig. 4. Leak from dye (arrow) was seen but the site was not identified due to inflammatory adhesion.

and hollow organs. This technique was effectively applied in three different cases. In the first two cases, it helped identify leaks in vascular structures, and in the third case, it was useful for detecting a leak in a hollow organ. In contrast to our approach, most other methods mainly use angiography to identify diseases or find leaks in blood vessels. Yet, they don't use these methods to detect leaks in the body's hollow organs.[2,4–7] This achievement bears considerable importance for practitioners in the field of forensic pathology, particularly in scenarios pertaining to allegations of medical malpractice.

The quality of images taken from postmortem angiography can be affected by many factors. For instance, air bubbles might create artifacts. Also, if blood vessels aren't completely filled after an injection, this could lower the image quality.

The type of contrast medium - the substance used to enhance the contrast of structures or fluids within the body in medical imaging -

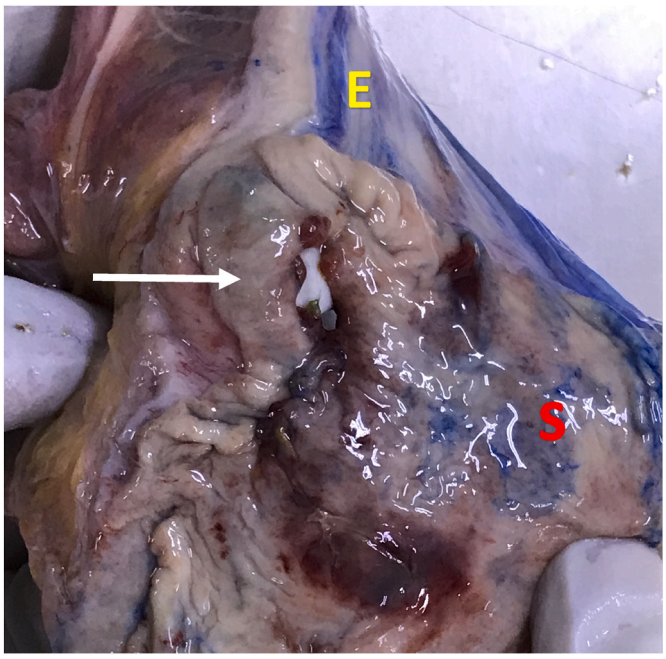

Fig. 5. Site of leak (arrow) from sleeve gastrectomy site inferior to gastro-esophageal junction. (E: esophagus, S: stomach).

matters too. If we use materials like Micropaque, the contrast medium can reach the smaller blood vessels and the arterial system effectively.[8]

It's also important to note that the thickness of the contrast medium plays a role. Thicker, or more viscous, contrast media may not penetrate the smaller blood vessels as effectively as less viscous ones. In simpler terms, runnier contrast media can get into small spaces easier than thicker ones.[9]

With the method we use, we avoid all those problems we mentioned earlier. We don't have to worry about air bubbles, for example. We've also standardized how we dilute the ink, which we've explained in the "Materials and Methods" section. We don't need to use different kinds of ink for different cases. Our methodology exhibits a high degree of consistency, thereby assuring the reliability and reproducibility of the outcomes each time it is implemented.

The interval between an individual's decease and the initiation of the perfusion process has a substantial influence on the outcomes of post-mortem angiography. The majority of methodologies retain their effectiveness within the initial 24 hours post-mortem. However, as this period is exceeded, the issue of extravasation begins to intensify, potentially compromising the quality of the angiographic images obtained.[6] Our method presents a significant advantage in that its applicability extends up to the point of cadaver decomposition, thus extending its utility in post-mortem examinations.

Other techniques involve injecting cadavers with a silicone mixture that hardens pretty quickly, usually within an hour.[2] But our method is different. It helps us spot where leaks are happening during autopsies in real-time. This can be really useful, like it was in our third case, where it gave us important clues for further investigation.

Ultimately, our methodology does not necessitate the use of an imaging machine within a room with lead-lined walls, as is the case with CT and MRI techniques. The detection of leaks can be accomplished visually, with the assistance of colored photographs and videos, which can be recorded and submitted as evidence. Moreover, this technique does not require specialized training beyond an in-depth knowledge of anatomy - a fundamental prerequisite for any forensic pathologist.

4. Limitations

The technique's limitations are evident in the requirement for steady hands during the procedure to avoid inadvertent vessel injury due to tremulous movements. Furthermore, accurate needle positioning within the vascular lumen is crucial to prevent intramural injection of the dye, which could lead to arterial wall dissection, the appearance of a bluish swelling, or even rupture. Notably, the technique does not necessitate specialized pumping, or perfusing techniques, as controlled syringe pressure is considered sufficient for vessel or organ perfusion. However, the risk of vessel rupture from excessive pressure or impaired visualization of the leak site from overly sluggish injection warrants attention.

Injections should ideally avoid close proximity to a leakage site, although this is not always feasible due to the potential invisibility of the leakage site to the unaided eye. Such circumstances can lead to misinterpretation or disputing the resultant artifact as a consequence of the needle tip. Utilizing an excessively dark dye is inadvisable due to the risk of causing superfluous field staining, which could confound any subsequent photographic documentation.

5. Conclusion

Using diluted ink as an injectable dye as a cheap and fast alternative to postmortem contrast imaging shows very good results when done properly. It helps the pathologist to identify the site of leak or hemorrhage with ease and can be performed readily during autopsy. It also provides more comprehended photos and videos that can be interpreted by any doctor without certain training or qualification. For the time being it can be performed on accessible vessels or organs during autopsy, however, virtually it can used in any vessel and open the doors for using vascular catheters in the future to reach inaccessible vessels or avoid injection near possible leakage site.

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Declaration of competing interest

None.

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