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REVIEW

Gastrointestinal and genitourinary fluoroscopy: a pictorial essay of a useful evergreen technique

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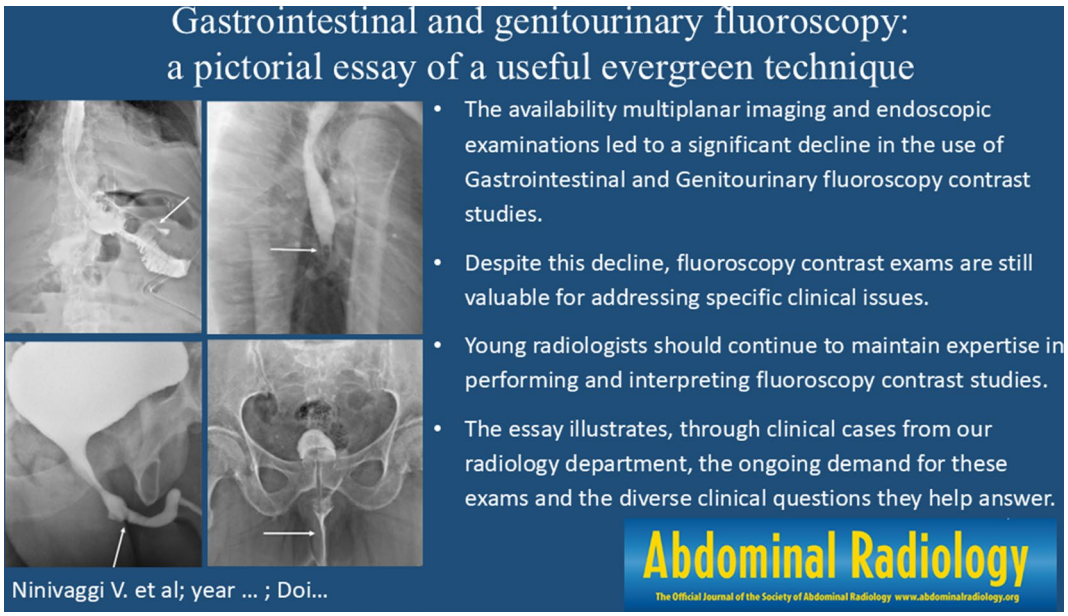
Abstract

Until recently, the use of direct contrast examinations with oral or intracavitary contrast agents was widespread in all general radiology departments. It provided significant answers to multiple clinical questions on the enteric organs and their mucosal surfaces. With the increased availability of CT and MRI, which also allow for the study of walls, as well as the accessibility of endoscopic examinations, the request and execution of fluoroscopy contrast studies have fallen considerably. Despite this, fluoroscopy contrast exams are still useful in specific clinical queries; therefore, radiologists should be able to provide their diagnostic contributions. This pictorial essay of clinical cases collected in our radiology department demonstrates the current demand for these examinations, the variety of the clinical questions we are called upon to answer and the need for continued expertise in execution and diagnostic interpretation of such studies.

Key points

- Fluoroscopic exams with contrast agents are still useful and allow us to reach a diagnosis in specific clinical questions.
- Fluoroscopic exams are still of current interest for young radiologists and the teaching in this field should be implemented.

Graphical Abstract



Keywords Fluoroscopy · Gastrointestinal · Genitourinary · Contrast agent · Barium · Iodine

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Introduction

Until recently, fluoroscopy with oral or intracavitary contrast agents was widely used in gastrointestinal (GI) and genitourinary (GU) examinations across radiology departments, providing valuable answers to common clinical questions regarding the study of cavities and mucosal surfaces in enteric organs. However, with the increasing availability of multiplanar imaging techniques, which allow for wall assessment, and the growing use of endoscopy, the demand for GI and GU fluoroscopy has declined. As a result, recent training has focused predominantly on multiplanar techniques, leading to reduced emphasis on fluoroscopy and less attention to its importance in residency programs. Since the 1990s, not all radiology residents at academic centers have received adequate training in these techniques, a sharp contrast to the more comprehensive training of radiologists in the 1980s. This has contributed to a decline in the technical quality of fluoroscopic examinations because fluoroscopy is operator-dependent and requires experience to master, with the quality of results relying on the operator's skill. As they gain more practice, they can achieve more accurate and reliable outcomes.

The reduced number of fluoroscopic procedures has also limited opportunities for residents to gain practical experience, further exacerbating the knowledge gap. Consequently, fewer trained radiologists have been able to pass on their expertise to newer generations, resulting in diminished familiarity, diagnostic and interpretive skills for these examinations [1–3].

Other factors contributing to the reduced demand for contrast-enhanced fluoroscopy may be economic in nature; despite their low cost, these procedures often receive insufficient reimbursement, leading healthcare facilities to prioritize other imaging modalities [3].

Nevertheless, fluoroscopic examinations remain essential in specific clinical scenarios where access to cross-sectional imaging is limited, maintaining their relevance in modern clinical practice. [4]. For these reasons, they continue to hold enduring value and interest in the field.

Indications

Fluoroscopic GU and GI examinations remain essential in certain specific studies and clinical situations. They are particularly useful and a standard part of modern radiology practice for assessment of anatomic alterations (hiatal hernia and fistulas), kinetics (dysfunctions of swallowing, transit, urination), evaluating ingested foreign bodies, and investigating post-operative complications (fistulas or dehiscence). In some cases, dynamic fluoroscopy is considered an appropriate imaging investigation by experts [3, 5].

Radiologists receiving these requests must be capable of providing expert input on several key aspects: selecting the most suitable exam to answer the clinical question, choosing the appropriate contrast medium, reducing radiation exposure, providing clear instructions to the patient during the examination, guiding the radiographer in the acquisition of the most suitable projections necessary for the clinical situation in question and ultimately drawing the correct conclusion.

Type of contrast agents

Contrast agents used in GU or GI are characterized by good viscosity, good radiopacity and radiation absorption. If the patient previously experienced hypersensitivity to a contrast medium, a treatment for allergic reactions is recommended or an alternative contrast medium should be used [1, 6].

In patients with an increased risk of aspiration, a low osmolar water-soluble contrast medium should be administered since aspiration of high osmolar ionic contrast agents may cause pulmonary oedema and barium contrast agents may cause pulmonary baritosis and death [7] (see Table 1).

Radiation dose

Following the directives, radiation dose should be measured and minimized as much as possible in all diagnostic procedures [8].

Keys for radiation dose reduction are:

- Limiting fluoroscopy time.
- Positioning the image intensifier as close to the patient as possible.
- Reducing the pulsed fluoroscopy frame rate.
- Using the "Save image" feature to avoid a spot fluoroscopic image.
- Track the exposure with a radiation badge [9].

Upper digestive tract: pharynx, esophagus, and stomach

The barium dual phase esophagography

The barium dual phase esophagography remains an accessible and cost-effective first line investigation for swallowing abnormalities, dysphagia, epigastric pain, clinical suspicion for acid reflux, esophagitis, gastritis, or ulcer disease, and in benign or malignant esophageal pathology as a post and

Table 1 Contrast agents [5]

Contrast agents			
	Barium	Water-soluble iodinated radiopaque	Non-ionic and ionic intraluminal organo-iodinated contrast agents
Indication	Indicated for anatomical studies with intact mucous membranes and walls high adhesion	Allow the visualization of the lumen and peristalsis They can be administered in viscera with non-intact walls (post-operative or perforation) Suspected aspiration: iso-osmolar non-ionic contrast agent (Iodixanol). Hyperosmolar non-ionic contrast agents can cause pulmonary edema.	Allow the visualization of the lumen
Characteristics	high opacity high adhesion high viscosity high stability	hyperosmolar (except for iso-osmolar Iodixanol) low adhesion to the mucosa	Good viscosity
Adverse effects	Penetration: send the patient manometric video-fluoroscopic study. Aspiration: antibiotic therapy or in severe cases bronchial lavage Peritoneal or mediastinal shedding: peritoneal lavage to ward off barium peritonitis or mediastinitis Barium retention in the colon: fluid intake and evacuative enemas Barolithe: surgical removal and evacuative enemas	Aspiration: in severe cases bronchial lavage	Intravasation: possible allergic reaction
Contraindications	Hypersensitivity to barium, to water-soluble contrast media, to iodine agents, to additives or indeterminate: treatment of allergic reaction, prefer another contrast medium if compatible with the question Toxic megacolon, intestinal infarction, or distal intestinal obstruction: do not administer any oral contrast agent, perform direct abdominal examination and/or CT		

pre-operative evaluation. It remains useful for patients who are intolerant of endoscopic procedures [3, 8].

Fluoroscopy offers continuous and real time monitoring of bolus transit from the oropharynx to the stomach and provide both good qualitative and potentially quantitative functional assessment of the esophagus including sphincter function, anatomical abnormalities, and mass lesions, with great sensitivity in detection of mucosal pathologic conditions [9].

However, barium swallows are operator and interpreter dependent and obviously expose the patient to ionizing radiation [10].

Before performing the examination, it is important to inquire about the patient's history of surgical or endoscopic procedures and any symptoms of dysphagia or odynophagia when swallowing liquids or solids.

In patients with suspected perforation or a high possibility of aspiration or recent abdominal surgery, water-soluble low osmolarity radiological contrast agents should be used. In other cases, barium solution and effervescent crystals should be administrated.

The procedure involves several projections with the patient standing, lateral and frontal phonation projections of the pharynx saying the letter "E"; followed by the ingestion of effervescent crystals, a small amount of water and then barium. The patient is then positioned in the left posterior oblique position to assess the esophagus and gastroesophageal junction while trying to hold in a burp. Frontal and lateral sequences of the pharynx when swallowing should be performed. Finally, the patient is placed in a prone right anterior position to obtain a distended view of the esophagus and check for reflux using neutral, Trendelenburg, or Valsalva maneuvers [9] (Fig. 1).

Foreign bodies stuck in the esophagus or stomach

A radiopaque foreign body lodged in the upper digestive tract should be visible during a direct examination, while a radiolucent foreign body requires the use of oral contrast agents. In this case it is mandatory to use only water-soluble low-osmolarity radiological contrast agents due to the risk of perforating the wall (Fig. 1).

Upper digestive tract perforation

Fluoroscopic studies with water-soluble low-osmolarity radiological contrast agents are indicated when in esophageal or gastric perforation is suspected whether traumatic,

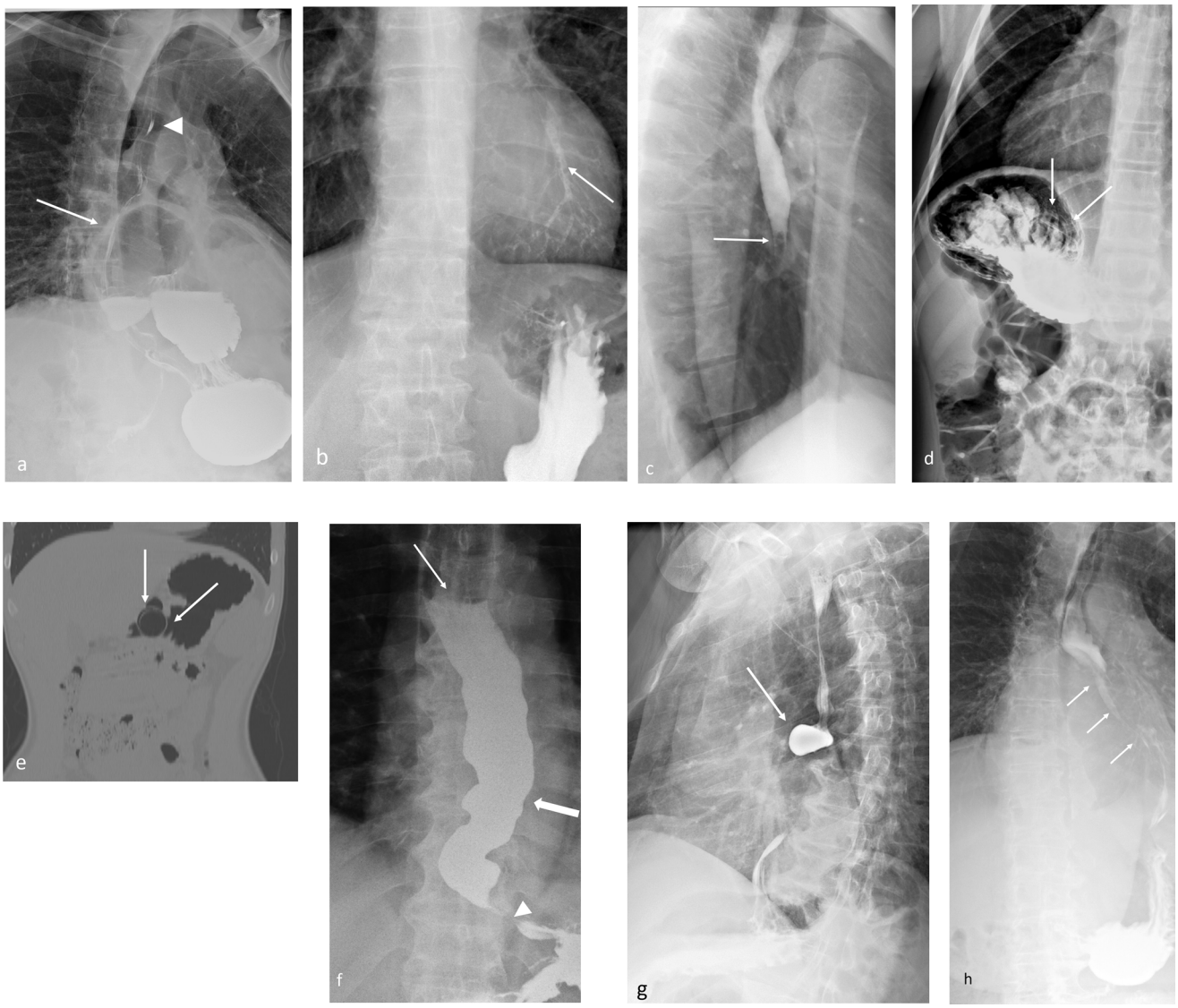

Fig. 1 Benign conditions in upper gastrointestinal tract. **a**: An elderly patient with heartburn, chest pain and digestive difficulties who refuses to undergo gastroscopy. Post-contrast fluoroscopic examination shows a sliding hiatal hernia (white arrow) which justifies the symptoms. Dyskinetic contractions of the esophagus and reflux are also observed (arrowhead). **b**: A patient with difficulty swallowing. Fluoroscopy shows normal opacification of the pharynx and delayed clearance of contrast agent. In the late radiogram, contrast agent in the left lower bronchus (arrow) confirms the suspicion of pharyngeal dyskinesia. Water-soluble low osmolarity radiological contrast agents were used due to the increased possibility of this occurring, with no clinical consequences for the patient. **c**: A patient with dysphagia after a meal, suspected of having meat bolus. After the ingestion of contrast medium, the piece of meat stuck in the lower part of the esophagus is outlined (arrow). Subsequent endoscopic procedure removed the bolus. **d**: A young patient who reports swallowing a plastic cap. On direct examination, no radiopaque foreign bodies were found. After oral administration of contrast, the shape of the ingested object (arrows) is clearly outlined, guiding the subsequent endoscopic procedure. **e**: A young patient who reports swallowing a plastic cap (Same patient of image "e"); the CT scan shows the plastic cap (arrows). Subsequent endoscopic procedure removed the foreign body. **f**: A patient with difficulty in swallowing, regurgitation of food and liquids, and chest pain. Post-contrast fluoroscopic examination shows achalasia with esophageal dilation (thick arrow), intraluminal fluid level (thin arrow) and narrowing of the esophagogastric junction (arrowhead). The patient subsequently underwent myotomy of the lower esophageal sphincter. **g**: A patient with dysphagia; the examination shows opacification of a saccular dilatation of the lateral wall of the esophagus consistent with a midesophageal diverticulum (arrow). The patient did not undergo surgery. **h**: A patient with mediastinal mass and dysphagia; the esophagogram shows a displaced and stretched appearance of the esophagus (arrows), with delayed contrast transit

iatrogenic, spontaneous or due to foreign body ingestion [5]. although a significant percentage of cases may yield false negatives. Some authors suggest in such cases, directly using CT with oral contrast material [11] or CT in cases of suspected perforation consequent pneumomediastinum bypassing fluoroscopic esophagography if no signs of perforation are present [12]. In suspect of fluoroscopic perforation esophagography may be helpful compared to CT with higher specificity (98,8% of esophagography versus 78,8% of CT) [11].

Postoperative upper gastrointestinal fluoroscopy

Despite ongoing debate regarding its routine use, upper GI fluoroscopy is still commonly requested by surgeons to detect fistulas or dehiscence after surgery [5, 13].

Fluoroscopic studies are useful in identifying the site and location of leaks and monitoring the recurrence while CT studies best report signs of perforation [3]. After surgery, water-soluble low osmolarity radiological contrast agents should be preferred. If there is any radiographical doubt or concern for additional complications such as an abscess, CT scan may be necessary.

For common GI surgeries such as total laryngectomy, Zenker's diverticulum repair, esophagectomy, sleeve gastrectomy, gastric bypass, and gastrectomy the radiologist should know clinical information, operative report symptoms and drain output to focus on the suspected site of fistula or dehiscence which will then lead the course of the examination.

In fact, the position of the patient during the fluoroscopic evaluation is crucial to detect a leak. Patients should be placed in various positions throughout the examination and the potential site of the complication be closest to the fluoroscopy table, in a gravity-dependent position to better detect the leak. Oblique images should be documented. Pre-contrast images should be obtained for comparison [14] (Fig. 2).

In the diagnosis of post-operative gastric fistula, fluoroscopic examination with contrast compared to CT has lower sensitivity and similar specificity and this fuels the debate on its real usefulness [13].

Stomach and duodenum

The study of the stomach and duodenum is routinely performed with endoscopy and cross-sectional imaging; however, fluoroscopy is indicated in cases where an anatomical and real-time functional assessment of motility is required and adds supplemental information and diagnostic-functional value to complete the evaluation and make a more confident diagnosis in cases of anatomical variants, myopathy, duplication cysts, mucosal hyperplasia or tumors.

Fluoroscopy is also indicated in the postoperative assessment to evaluate complications and extraluminal leaks.

Fig. 2 Upper gastrointestinal surgery. **a**: A patient after gastric bypass on the third postoperative day. The surgeon suspects a fistula. Anastomosis appears normal after ingestion of a water-soluble contrast medium. The image shows a faint outline (arrow) at the anastomotic site, initially suspected of fistula. After waiting, the opacified area, and the image is mobile under the scope, suggesting that it is a part of the efferent loop. **b**: A patient with recent gastrectomy, suspected fistula after oral administration of radiopaque contrast medium. Extraluminal extravasation of contrast medium is adjacent to the suture (arrow). **c**: A patient with dysphagia following partial gastrectomy for cancer and gastrocolic anastomosis (arrow). The suspected anastomotic stricture was not confirmed by the exam

The single or double contrast technique can be used, employing barium as the contrast medium in the absence of suspected perforation or recent surgery.

It is still indicated in cases where endoscopy is not tolerated for the study of inflammatory lesions of the mucosa or tumors. [15].

Low digestive tract

Small bowel

The fluoroscopic study of the small is currently decreasing due to the higher sensitivity of CT and MRI in the study of the intestinal lumen, the wall, and the surrounding structures, even with distension of the lumen (CT o MR enterography).

An indication of fluoroscopic small bowel examination could currently be follow-through exam, which, after studying the upper digestive tract, aims to evaluate the small intestine to assess for adhesions, narrowing, extraluminal compressions and motility disorders. The contrast medium used is barium, provided that there is no recent surgery or suspected perforation; fasting is necessary for at least 8 h. Radiographs are taken intermittently every 15–45 min until the contrast reaches the colon, a process that can take up to 2 h [16]. Due to the long duration, this exam is not well-received by patients.

Large bowel

The double or single contrast enema was once a commonly requested examination for the evaluation of the mucosal surface of the colon, wall alterations and suspect of obstruction. It has been replaced by CT colonography or endoscopic examination. Despite this shift, single contrast enemas are still used in specific cases, such as when patients refuse endoscopy or during the postoperative phase [17].

The intracavitary fluoroscopic study with contrast injected into the rectum by catheter (water-soluble low osmolarity radiological contrast agents) is employed in postoperative evaluations to look for fistulas or dehiscence, and then correlated with CT scan (Fig. 3).

Urinary tract

Fluoroscopic study of the urinary tract is still requested for a wide range of clinical questions due to its ease of execution, widespread use, and the anatomical and functional information that it provides (Fig. 4). Iodinated water-soluble contrast agents are used to perform the studies described below.

Indications are dysfunctional voiding, suspect of outlet obstruction, hematuria, congenital anomalies of the genito-urinary tract, pre- and postoperative evaluation of the urinary tract and trauma (Fig. 5).

Urethra

Both ascending and descending urethrography offer valuable insights into the pre- and post-operative conditions of the urethra, helping guide patient management.

Retrograde urethrography

In this procedure a Foley catheter is secured a few centimeters into the urethra. The urethra is opacified retrograde with 20–30 ml of iodinated contrast agent. Radiographic images in oblique projection should be acquired when the urethra is sufficiently opacified and distended by contrast agents.

Anterograde urethrography

In This procedure the bladder is filled with a contrast water soluble agent (diluted in water) via Foley catheter; then after catheter is removed, images are captured during active voiding when the urethra is opacified in oblique projections.

Cystography

For cystography the bladder is filled with water-soluble contrast agents via a Foley catheter. The pre-contrast image is obtained for comparison. Early filling and full volume images of the bladder should be obtained to assess the extensibility, the morphology of the organ, and any potential ureteral reflux. Lateral and voiding images could complete the evaluation. Cystography can provide information about the appearance of the bladder in a preoperative setting (kidney transplant, colovescical fistula), post-operative (cystectomy and reconstructive surgery, research of fistula), and functional data [18, 19].

Uterus and fallopian tubes

Hysterosalpingography (HSG) is an important radiologic procedure in the investigation of infertility providing detailed information of the uterine cavity, the lumina, and the patency of the fallopian tubes [5]. The evaluation of the uterine cavity may reveal congenital malformations such as unicornuate uterus, or irregularities of the mucosal surface such as adenomyosis, submucosal fibroid or endometrial polyp protruding into the uterine lumen.

Fig. 3 Lower gastrointestinal studies. **a**: Endorectal enema in a patient following sigmoid resection shows stenosis of the colorectal anastomosis (arrow). **b**: A patient who underwent sigmoid resection and rectal anastomosis. The clinician suspects a postoperative fistula. The injection of radiopaque contrast medium by catheter shows regular opacification of the loops without extraluminal contrast spills. **c**: A patient with constipation and fecal occult blood who refuses a colonoscopy. Colonic enema shows neoplastic stenosis of the intermediate sigmoid (arrow). The patient was sent to the oncologist

Due to recent advances in reproductive medicine, the examination is commonly requested. HSG has a high sensitivity and specificity for the evaluation of tubal patency, shown in prospective series (92.1% and 85.7% respectively) [3].

The procedure is performed in the first half of the menstrual cycle when the endometrium is in the proliferative phase. A negative pregnancy test is mandatory to avoid irradiation. A negative vaginal swab for most common pathogens is necessary to avoid ascending infections. The procedure is contraindicated in case of recent uterine surgery.

An endoluminal organo-iodined contrast agent is injected into the uterine cavity via a catheter fixed at the cervical ostium. In a normal exam the uterine cavity, fallopian tubes and their adjacent peritoneum are normally opacified [20, 21] (see Fig. 6).

Conclusion

Fluoroscopic techniques continue to be a valuable skill for radiologists, especially in general radiology departments. It is important that these procedures remain an integral part of training for young radiologists, ensuring they are equipped with the necessary expertise to conduct such examinations effectively. The future of fluoroscopy is likely to involve its integration with advanced imaging techniques, such as CT and MRI, to improve diagnostic accuracy and provide a more detailed view of anatomical structures and abnormalities.

Technological advancements are also expected to enhance image resolution while reducing radiation exposure during fluoroscopic procedures, making them safer and more effective.

Artificial intelligence could play a key role in advancing fluoroscopy by assisting with image interpretation, automating routine tasks, and enabling faster detection of patterns or anomalies.

In addition, the development of more advanced training tools, including virtual reality and simulation-based

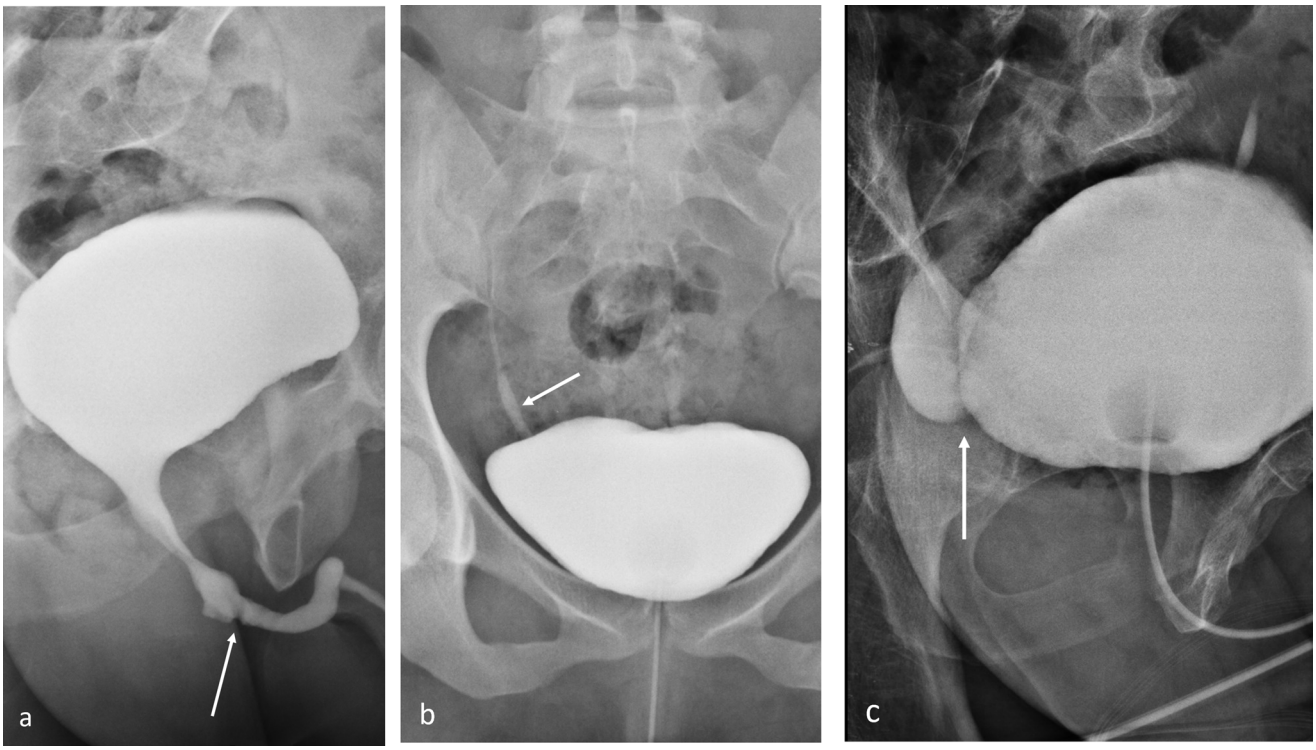

Fig. 4 Urinary tract. **a**: A patient with stranguria and recurrent urinary tract infections. During ascending cystography, focal stenosis (arrow) is evident at the middle third of the penile urethra. This was confirmed by subsequent voiding cystography. The patient underwent surgery with subsequent disappearance of symptoms. **b**: A kidney transplant candidate. A cystography was performed to assess bladder wall distensibility and capacity, both of which appeared normal. At medium bladder filling, right ureteral reflux is observed. **c**: A patient with recurrent urinary tract infections: the bladder appears normal during filling. At initial filling, reflux and opacification of ureterocele are observed

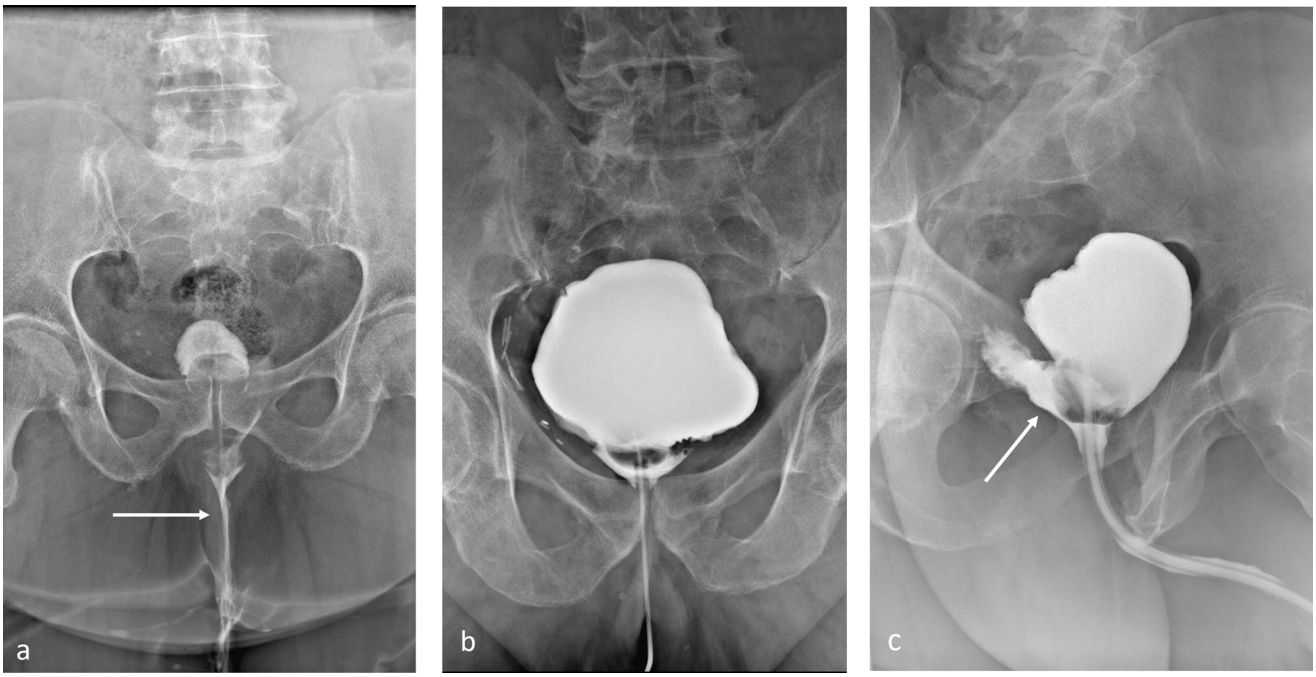

Fig. 5 Urinary tract surgery. **a**: Patient with previous hysterectomy for cervical cancer and clinical suspicion of vesicalvaginal fistula. After administraring radiopaque contrast medium through the catheter, opacification of the vulva is observed (arrow), confirming the diagnostic suspicion. The patient was operated on with good results. **b**: A retrograde cystography study in a patient with radical cystectomy and ileal neobladder shows normal appearance and distension of the viscera. **c**: A patient with recent prostatectomy, suspected anastomotic leak. Retrograde contrast medium administration reveals extravasation into the surgical bed

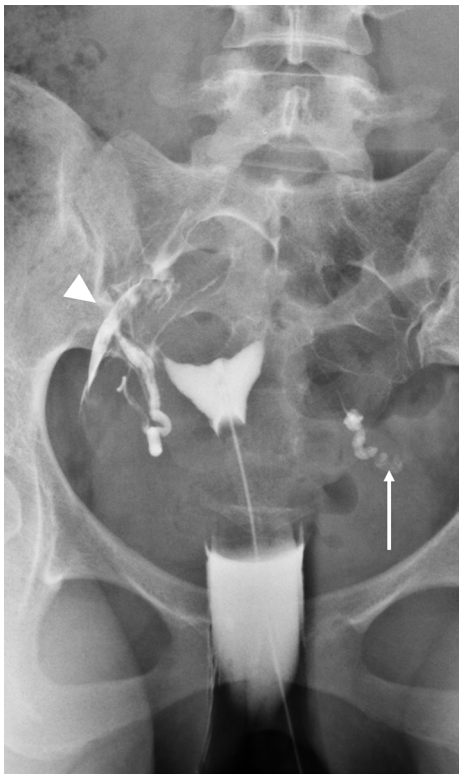

Fig. 6 Female genital tract. Image: A patient with infertility: regular opacification of the uterine cavity after administration of contrast medium. Regular opacification of the uterine cavity after contrast medium administration. The right fallopian tube is filiform, with normal passage of contrast through the peritoneum (arrowhead). The left tube is filiform and convoluted, with delayed contrast passage into the peritoneum, suggesting adhesions

platforms, could help radiologists and clinicians improve their skills in performing and interpreting fluoroscopic studies.

These innovations point to a future where fluoroscopy becomes more precise, efficient, and accessible in clinical practice.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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