How safe is Urology? An updated perspective regarding the use of ionizing radiation in the most common urological interventions

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ABSTRACT

The principle of minimal invasiveness is one of the pillars of today's medicine and affects the field of urology as well. Many intervention techniques proposed over the last decades aim to decrease the invasiveness, maintaining or even increasing the efficiency of the classic ones. However, there are still risks associated with surgical interventions, direct or indirect, which target both the patient and the medical staff, so that updating about the potential risks and protective measures is absolutely necessary to ensure an optimal operating climate, a good health for all the people involved in the medical act. The endoscopic approach in urology, very frequently, is carried out under imaging guidance. Fluoroscopy is one of the most used intraoperative guidance techniques, based on the use of ionizing x-rays, but there are alternatives. The current perspective must identify the best technique, at the best moment, for maximum efficiency and safety and take care including the development of the national health system, with the patient at the center of interest, but without ever neglecting the medical staff.

Key-words: radiation, exposure, double J stent, ureteroscopy, PCNL, risk, cancer.

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EDITORIAL

Minimally invasive surgery principle has become widespread in among the doctors of different specialties around the world in the last decades and it represents one of the main criteria for classifying treatment lines, in addition to efficiency and safety. Considering that, modern urology proposes multiple types interventional techniques, which replace or work complementary to the classical ones, including the endoscopic urinary drainage, using autostatic double J stents, the ureteroscopy or the percutaneous nephrolithotomy.

Despite the minimally invasive character of the endoscopic approach, it still it still has some harmful effects on the patient and/or the surgeon.

Fluoroscopic guidance is the most frequently used modality during urological procedures, having the role of controlling the final position of the double J stent inside the urinary tract. It is also used in other urological interventions, especially in the management of urinary stones. Ultrasonography is another well-known form of imaging guidance.

Nowadays, the mechanism of fluoroscopy guidance involves the use of X-ray beams that penetrate the body tissues. After that, they are captured behind the object by a detector and displayed on a digital screen. The major benefit of the maneuver is the possibility to evaluate the dynamics of body segments, the mobility of instruments and the contrast material.[1] However, the use of ionizing radiation represents a risk factor for the development of neoplastic pathologies and it affects every person involved in the process.

Acquired malignancies after the exposure to low doses of ionizing radiation are difficult to appreciate, as they require a long period of observation, but there is certainly an inter-relationship generally accepted by the specialists, so the current recommendations support the idea of minimizing both the time of exposure and the amount of radiation.[2]

According to the ICRP (International Commission on Radiological Protection), the maximum limit dose of radiation exposure must not exceed 20 mSv/year on average over 5 years for workers.[3] In contrast to people at the workplace, the maximum dose of exposure for general population is set around 1 mSv/year.[4]

There are two types of effects generated by ionizing radiation on the human body, depending on the time elapsed from exposure to manifestation, based on deterministic effect or tissue reaction (visible, documented manifestations that appear a short time after exposure) and stochastic effect (genetic disorders or neoplastic diseases, which require a longer time to appear and are therefore much more difficult to document). Since stochastic effects do not have a minimum exposure threshold necessary for their occurrence, it is currently considered that there are risks even at the lowest doses. Also, we must remember that exposure to radiation is cumulative, and the resulting effects may be different from individual to individual due to differences in radiosensitivity.[5]

Back in 2004 the annual incidence of global cancer related to ionizing radiation from medical imaging was about 3%.[6]

Two years later, in 2006, the radiation exposure for people during medical imaging procedures, increased by 600% compared to the mid-80's, exceeding at that time, in terms of quantity, the exposure from natural sources.[7] Even if there is a lack of data, the trend of the last 2 decades is considered to be an increasing one.

Considering that exceeding the safety limit of 20mSv/year, for a maximum duration of 5 years or 50mSv/year, is associated with a risk of developing a deadly form of cancer (1 case per 1000 people), the urological community received recommendations to find solutions in order to minimize the exposure to ionizing radiation, both for patients and medical personnel. The necessary measures must follow the ALARA (As Low As Reasonably Achievable) concept and target both the preoperative investigations and the intraoperative moment. The information campaigns targeting the patients, the biometric document that records previous exposures to radiation (passport), the use of intraoperative

dosimeters, the means of protection for both the patient and the staff, the distance between radiological beam adn surgeon, the reconfiguration of the equipment, the specialized training sessions , but also the development of interventional techniques without the need for radiological guidance are examples of solutions in order to minimize the exposure.[8]

In 2019, the UK FLASH study, managed to illustrate a quantitative evidence of radiation exposure for patients during urological procedures, such as double J stent installation/replacement, ureteroscopy and percutaneous nephrolithotomy. It also established reference levels for these procedures.[9]

Reference levels for intraoperative radiation

PCNL (Percutaneuous Nephrolithotomy)	24.1Gy/cm2
Ureteroscopy	2.3Gy/cm2
Stent insertion/replacement	2.1Gy/cm2

Table 1 - Adapted[9].

The FLASH study also observed differences in fluoroscopy time and radiation doses between centers, between surgeons and radiologists, but also between surgeons with different experience.[9]
In Australia, during 2020-2021, 34,690 ureteral stents were installed and 61,300 cases of urolithiasis required hospital care. The data collected in the period 2012-2022, from Dubbo Base Hospital, show that the average exposure to radiation during the procedure of inserting Cook probes in emergency was 12.6 mGy, 2.94 Gy/cm2 and the average fluoroscopy time was of 44.5 s. It didn't find any major differences related to operator experience.[10]
The protective equipment used in the operating room is very important for all the medical personnel nvolved, but especially for the main operator. As it I appears from a study carried out between October 2018 and September 2019, at the Gil Medical Center in South Korea, the appropriate use of protective equipment can reduce the level of radiation exposure by up to 2% of the annual limit allowed. Although during urological procedures the upper extremities of the operator are exposed, wearing gloves and protective glasses also suggests an important decrease in the level of direct exposure to radiation. Regarding the number of retrograde renal surgeries that can be performed within the acceptable range of radiation exposure, it has been determined that urologists without a full-body lead apron can perform only 85 ureteroscopies, while optimally equipped operators can performed up to 517 ureteroscopies/year.[11]

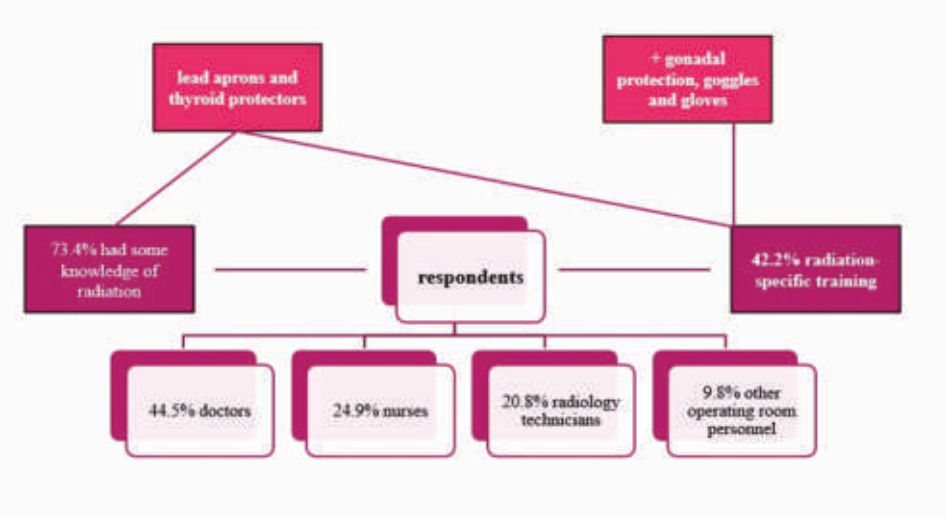


Figure – Despite the existing protection measures, there are still gaps among the medical staff regarding information, training and implementation of good practice rules against exposure to ionizing radiation[12].

Studies in the field of ionizing radiation, the risks associated with medical investigations, as well as the recurrence of urological interventions under imaging guidance, have provoked the medical community in the spirit of developing complementary or even alternative techniques, which minimize the exposure of the patient and the medical staff to potential unwanted adverse reactions.

Ultrasonography was introduced early in the field of urology and quickly gained notoriety for its efficiency and non-invasiveness. Ultrasound explorations for diagnostic purposes, ultrasound guidance as imaging support in surgical interventions, but also post-operative follow-up represent the main uses of ultrasonography in urology.

Pregnant people and children are high-risk groups compared to the harmful potential of ionizing radiation, so in most cases fluoroscopy is contraindicated as a method of diagnosis or imaging guidance.

Ureteral obstruction, most often due to the presence of urinary stones, affects pregnant women alike, and there are even arguments regarding the increase in the risk of developing urinary stones during pregnancy due to some favorable factors, such as the increase the amount of calcium, uric acid and sodium in urine, but also because of changes in pelvic mechanics and hormonal activity. Doppler ultrasonography has proven to be an effective diagnostic method through the direct visualization of the calculus, urinary tract distention, but also through indirect methods such as the measurement of vascular resistance at the level of the renal circulation. In addition, retrograde ureteroscopy and mounting of double J stents under visual and ultrasound control can represent a method of good management of the obstructive event.[13]

Fluoroscopy can be replaced by active intraoperative ultrasound guidance and the acquisition of only a simple abdominal x-ray at the end of the procedure to confirm the position. In such a situation, the exposure to ionizing radiation is reduced to negligible levels, while maintaining the efficiency of the procedure and achieving the goal of decompressing the urinary tract.[14]



Figure 2 – Obstructive calculus at the level of the pyelo-ureteral junction, which associates secondary HN grade II. (Central military hospital archive)

In North America, several works have been published that deal with the subject of mounting Cook probes outside the operating room, reducing to a minimum the material resources needed for the intervention, but also the discomfort created for the patient. Nourpavar et al. in 2016, Heiko Yang et al. in 2021, but also David Chung et al. in 2024, reported high success rates (70%-100%) using the same technique. They used the cystoscopic assembly, hydrophilic guides, active ultrasound guidance during the procedure and simple abdominal radiographic acquisitions at the end. The interventions were carried out under local or intravenous anesthesia. In all cases, the main failure criterion was represented by the presence of obstructive calculus at the level of the proximal ureter, practically a situation that affects the efficiency of the surgical act regardless of the form of imaging guidance used.[15 16 17].



Fig 3 –The double J stent at the level of the Pielo-Calyceal Space (Central military hospital archive)

Stenting the urinary tract is not the only procedure that requires imaging guidance. The elaborate management of urinary lithiasis, practically the form of elective treatment, involves interventions such as retrograde/anterograde ureteroscopy plus lithotripsy or percutaneous nephrolithotomy. A review published in April 2023 compared the stone free rate for a large number of ureteroscopies, respectively percutaneous nephrolithotomies, with or without fluoroscopy. The results further support the plausibility of avoiding ionizing radiation in selected cases.[18]

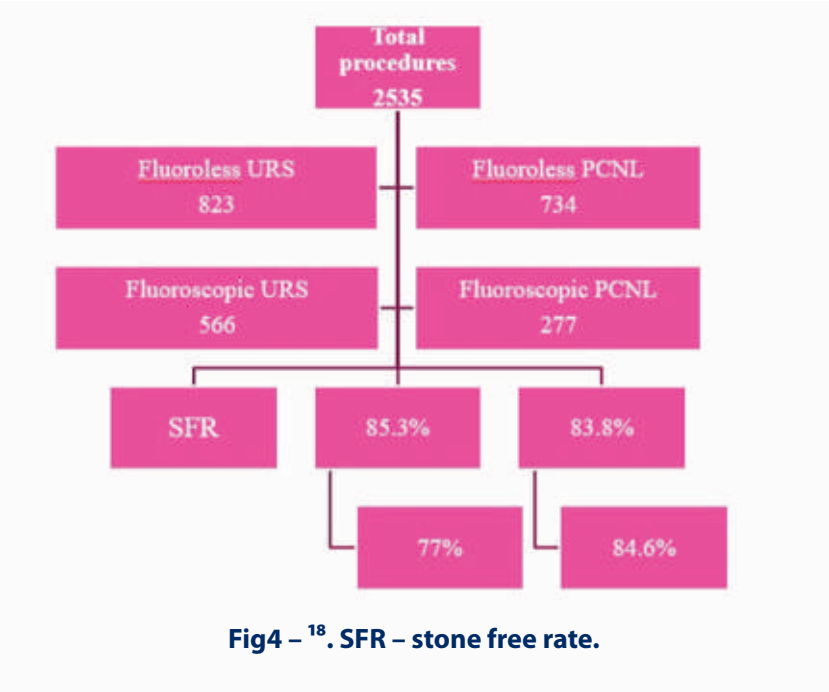


Fig4 – [18]. SFR – stone free rate.

CONCLUSIONS

Double J stents placement, as well as other endoscopic or percutaneous procedures, are not completely free of risks.

Double J stents placement, ureteroscopies, but also percutaneous nephrolithotomies can be performed with the minimum necessary fluoroscopic control, or only under ultrasound guidance in selected cases.
The need of developing a national study to collect important data on radiation exposure in urology is obvious (measurements, comparisons between urological units, centralization of data).

It is truly necessary to elaborate a good practice guide regarding exposure to radiation exposure in urology according to ALARA principle (standardization of urological procedures, periodic measurements and notifications in case of exceeding the maximum allowed/doctor/unit, standardization of equipment configurations, etc.).
It is mandatory to carry out periodic specialized training sessions for medical personnel (doctors, nurses, auxiliary personnel with risk of exposure).
Material resources represent a major component in the development of the health system, so continuous investments in the infrastructure are totally necessary (protective equipment for patients and personnel involved in the medical act, specially dedicated rooms, etc.).
Evaluation of the efficiency, safety and minimal invasiveness of alternative intervention techniques in the urological field (ultrasound control, visual control, etc.).

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