Working with radiation in pregnancy: a guide for cardiologists

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Women remain under-represented in cardiology and one frequently cited concern is that of radiation exposure in pregnancy.[1]

This article aims to clarify the actual risks of radiation to pregnant cardiologists and to describe how these risks can be mitigated.

X-rays are at the short-wave end of the electromagnetic spectrum and produce high-frequency energy which can ionise atoms. The effective dose is measured in Sievert, defined as the whole-body dose weighted by organ sensitivity. In pregnancy, there are concerns about the risk of radiation to the fetus and also less recognised risks to the mother.

The mean background dose of radiation in the UK is 2.2 mSv/year,[2] and the total occupational dose permitted for the fetus in pregnancy in the UK and Europe is 1 mSv,[3] with a higher limit of 5 mSv in the USA.[4] In most cases, the actual dose is far lower than this. A series of five operators performing interventional and electrophysiology procedures during pregnancy found that the abdominal dose was well below the reference limit and in several cases no higher than the background radiation level.[5] Studies on non-pregnant operators confirm that the dose to the abdomen is generally extremely low, often below the limit of detection.[4] There is no level of radiation which is absolutely known to be 'safe', but nevertheless, this level of dose is not associated with significant changes in foetal or childhood health. Deterministic effects on the fetus such as miscarriage, decreased growth and lowered IQ require far higher doses; similarly, there is no measurable increase in rates of childhood leukaemia at doses under 5 mSv.[6]

Operator dose is important for all operators throughout their careers, but in pregnancy there is the additional vulnerability of metabolically active breast tissue. The breast is thought to be more sensitive to radiation in pregnancy and in the first month postpartum because of peripartum proliferation of glandular breast tissue. In the absence of humeral shields, the axillary portion of the breast can be exposed to radiation, especially if the arm holes of the leads are too large.

In terms of risk mitigation, the employer's responsibility to enforce the 1 mSv dose limit does not start until the pregnancy is reported, and therefore this should be done as early as possible (table 1).

Increased operator experience has been shown to be associated with decreased radiation doses; however, trainees working in pregnancy can still be well below acceptable dose limits. Operator training specifically on radiation protection has been demonstrated to lead to dramatic reduction in patient (and hence operator) dose,[7] so this is key for both senior and inexperienced operators.

Careful use of X-ray equipment can significantly reduce dose. It is often possible to reduce frame rate, collimate more closely and minimise use of steep angles while still getting diagnostic images. 'Save fluoro' images should be used as often as possible rather than full acquisitions, for both coronary and pacing/EP procedures.

Distance from the X-ray source is important; operators should step away where possible. Using injection pumps and longer catheters facilitates this. Ceiling-suspended lead acrylic shields should be positioned appropriately in all cases. Radiation protection pads placed on the patient reduce scatter to the operator.

In terms of personal radiation protection, operators should wear lead aprons that are at least 0.5 mm equivalent—this will stop 98% of scattered radiation vs a 0.25 mm lead which stops 96%.[8] It is important to understand the degree of protection that leads provide—some '0.5 mm' leads provide 0.5 mm protection when overlapped but are only 0.25 mm in non-overlapped regions—it is therefore crucial that they overlap enough throughout a pregnancy. Humeral shields should be available. Thyroid shields and lead glasses should be worn, and lead caps and shin shields should be considered. There is no evidence to support wearing additional abdominal leads, provided that the apron used is 0.5 mm equivalent, and wearing extra leads may increase risk of musculoskeletal injury.

Table 1 Summary of radiation risk mitigation in pregnancy

Inform employer of pregnancy	Risk assessment and responsibility to enforce pregnancy-specific dose limits, can seek advice from radiation protection supervisor
Operator radiation protection training	Shown to reduce patient and operator dose
Careful X-ray technique	Collimation, store fluoro rather than acquisitions, reduce frame rate, minimise use of steep angles
Optimal use of screens and shields	Position screens appropriately, consider use of radiation protection pads on the patient
Distance from radiation source	Step away where possible using long catheters/automated injectors to facilitate this.
Optimal personal protection	0.5 mm leads which fit adequately throughout pregnancy with humeral shields, if possible, to stop 98% of scattered radiation reaching the operator; thyroid shield, lead glasses±shin shields and lead cap; no need for additional abdominal leads

SUMMARY

In summary, it is legal to work with radiation while pregnant in the UK and in many other countries, and the risks can be mitigated to an acceptable level. A better awareness of radiation protection—with more use of low-dose techniques and protective equipment—would benefit all operators and not just those who are pregnant.

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