Title: Pregnancy screening strategies for diagnostic nuclear medicine: survey results from Australia and New Zealand

Running foot line: Pregnancy screening strategies: survey

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ABSTRACT

The ionising radiation used in diagnostic nuclear medicine procedures has the potential to cause biological harm to a foetus. Although the risks are relatively small, it is recommended that all female patients of childbearing age are questioned regarding their pregnancy status prior to administration of the radiopharmaceutical. This can be a sensitive situation especially for certain types of patients, such as teenagers. Currently there are no guidelines that detail how to question the patient. Previous studies have revealed the lack of a consistent approach in this area.

Aim: To investigate current practice for pregnancy screening prior to diagnostic nuclear medicine procedures in Australia and New Zealand and to determine if a standardised practice guideline is required.

Methods: An online survey was administered via SurveyMonkey from October to December 2011. ANZSNM members were invited to participate. The questionnaire consisted of 30 questions divided into four sections: demographics, policy and regulations, current practice, and open ended clinical scenarios.

Results: 335 responses were recorded from participants in all states and territories of Australia and New Zealand. 90% were nuclear medicine technologists. Participants reported a low awareness of radiation policy and regulations but demonstrated good knowledge of the relative risk to the foetus from commonly performed procedures. The most common minimum and maximum age to question patients was 12 years (32%) and 55 years (42%) respectively, although the range was from 10-60 years. Verbal questioning (44%) was most commonly used approach. Pregnancy testing was used by 72%; usually if the patient indicated she was unsure of her pregnancy status. Responses to clinical scenarios were varied and these will be discussed in a subsequent paper.

Conclusion: The survey revealed a lack of awareness of government regulations and departmental policy regarding radiation protection. The study demonstrated wide variety in pregnancy screening strategies used to determine the pregnancy status of patients prior to
diagnostic NM procedures, indicating that standardised practice guideline is required for Australia and New Zealand.

**Keywords:** ionising radiation, pregnancy, foetal exposure
INTRODUCTION

Radioactive materials that emit ionising radiation are utilised in nuclear medicine to perform diagnostic imaging procedures and therapeutic dose administration. Measures for the protection of the foetus is necessary because ionising radiation has the potential to cause biological damage in humans, and foetal tissue is particularly sensitive to these effects (1). The potential biological effects from irradiating a foetus with ionising radiation can be “teratogenic, mutagenic or carcinogenic” (2).

Therapeutic nuclear medicine entails the administration of large doses of a radiopharmaceutical designed to destroy specific cells while diagnostic nuclear medicine procedures involve considerably smaller doses to image the physiology and anatomy of the body. It is imperative to determine if a female patient could be pregnant prior to administration of the therapeutic dose to protect the foetus. Guidelines published by government and regulatory bodies, such as ICRP Publication 84, Pregnancy and Medical Radiation (2000) (3) and ARPANSA 14.2, Safety Guide for Radiation Protection in Nuclear Medicine (2008) (4), contain instructions on how to determine the pregnancy status of the patient prior to radiopharmaceutical dose administration. Pregnancy testing within 24 hours of therapy administration is mandatory due to the size of the doses used to ensure any unborn foetus is not irradiated (4). However, for diagnostic imaging procedures, where the amount of radiation administered is considerably smaller and the risk to the foetus is less, the guidelines are less clear. It is recommended that all women of child-bearing age are questioned regarding their pregnancy status prior to diagnostic imaging procedures and that signs should be placed around nuclear medicine departments asking patients to notify staff if they think they may be pregnant (4). However, there are no instructions on how to question
the patient or how to determine which patients should be classed as within child-bearing age.

In 2008, the American College of Radiology developed a practice guideline to provide information regarding foetal risk from ionising radiation and instructions to assist radiographers on how to screen for pregnancy prior to radiological examinations (5). These guidelines did not include information for nuclear medicine procedures. In 2009, a review of European practice suggested there was a lack of consistent practice in this area and that more research was required (6).

In 2011, the authors conducted an interview study in Australia to identify the methods used to question female patients about their pregnancy status prior to diagnostic nuclear medicine procedures and any problems that nuclear medicine scientists (NMS) associate with this. The study reported that a variety of methods of questioning were used in different departments, and even within departments, and that the most common form of questioning was a verbal approach with the NMS often using their discretion as to which patients to question (7). A limited number of interviews were conducted therefore the authors decided to investigate whether the findings were representative of current practice in nuclear medicine across Australia and New Zealand. A questionnaire was developed from the findings to investigate knowledge of pertinent regulations, methods of questioning, determination of age range for screening, use of pregnancy testing, and knowledge of foetal risk from ionising radiation. The questionnaire was used to conduct a nationwide survey of nuclear medicine personnel in Australia and New Zealand.

The aim of the study is to investigate current practice for pregnancy screening prior to diagnostic nuclear medicine procedures in Australia and New Zealand and to determine if a standardised practice guideline is required.
METHOD

Ethics approval was gained from the University of Newcastle Human Research Ethics Committee prior to commencing the study. (Approval number H-2009-0270).

A SurveyMonkey questionnaire (supplemental data file) consisting of 30 items divided into four sections was developed from the findings of the interview study (7). Questions in sections 1-3 were mainly closed responses, while Section 4 sought open-ended responses to four clinical scenario questions. In Section 1, the demographic questions (items 1-8) asked about gender, profession, years of experience and place of practice to help categorise participants and determine if the study sample is representative of the nuclear medicine professional community in Australia and New Zealand. Section 2 (items 9-13) investigated participants awareness of departmental policy and government regulations relating to pregnancy and medical radiation. Section 3 (items 14-25) investigated current practice in determining pregnancy status in nuclear medicine. Participants were asked to nominate the minimum and maximum age that they routinely question their patients and give a rationale for this age. The questions asked which method of questioning was used, whether verbal, verbal with a signature, or a written form; and whether any questions about last menstrual period (LMP), contraceptive use, or menopause and hysterectomy were included. Participants were asked if they used pregnancy tests in their department, how often they are used, which type (serum or urine), and in which circumstances they were used. Question 25 asked participants to rank eight (8) diagnostic procedures in order of risk to a foetus from the exposure to ionising radiation from each procedure.

Section 4 (items 26-30) included four open response questions on how to question the patient in a series of clinical scenarios and one open response asking for any additional comments. The results from this section will be discussed in a subsequent paper.
The questionnaire was administered as an online survey via SurveyMonkey and was open for two months from 11\textsuperscript{th} October to 12\textsuperscript{th} December, 2011. An invitation to participate was published in the September 2011 issue of the Gamma Gazette (the journal of the ANZSNM). It was also emailed to members of the ANZSNM with a link to the survey. In April 2011, there were 1115 members of the ANZSNM, of which 839 were NMS (J. Anderson, 2011 – Personal Communication).

Data analysis was performed using descriptive statistics and open-ended responses were manually coded using thematic analysis.

**RESULTS**

*Demographics*

A total of 335 responses were recorded and 66% were from females. The majority of participants were NMS (90%). The remainder consisted of 6 physicists and 33 nuclear medicine physicians. The majority of participants were experienced nuclear medicine professionals with almost half (48%) reporting that they had more than 10 years of experience in their profession and 88% having more than 3 years of experience. The type of practice that participants were employed in was relatively evenly split between public practice (48%) and private practice (52%) departments. The majority of participants practiced in New South Wales (38%) and Victoria (25%), although responses were recorded from all states and territories of Australia and New Zealand. The survey participants are believed to be representative of the nuclear medicine community in Australia and New Zealand. (J. Anderson, 2011 - Person Communication)
Policy and Regulations

In response to the question asking if they were aware of a written policy regarding checking for pregnancy prior to diagnostic procedures in their department, 65% (193/295) indicated “Yes” with 63% (121/193) having read it within the last 12 months (Figure 1). When asked if they were aware of any government regulations regarding how to determine the pregnancy status of patients prior to diagnostic imaging procedures, only 28% (85/298) answered “Yes”. Participants who answered that they were aware of government regulations were asked to briefly state, in their own words, what was included in the regulations (Figure 2). Participants were then asked if they had read relevant sections in either ICRP 84 (3) or ARPANSA 14.2 (4). The majority of participants (76% and 64% respectively) indicated that they had not read these documents.

Current practice

Age: The most common minimum age reported to be used for questioning a patient about pregnancy was 12 years and the most common maximum age was 55 years. The age range for questioning was 10-60 years. The number of responses for each age category for male and female participants is displayed in Figure 3. There was no significant difference between the male and female responses ($p=0.08$).

Participants were asked to state a rationale for using a particular minimum and maximum age to question their female patients about pregnancy. For the minimum age: 6 participants stated it was departmental policy; 6 participants had personal experience of a girl being pregnant at that age; and 18 participants said it depended on the maturity of the patient. The most commonly used rationales for minimum age were: the age menstruation begins (113); patients becoming sexually active at this age (33); and at that age they would ask if patient is menstruating first (21) (Figure 4).
For maximum age to question patients: 10 participants stated it was departmental policy, and 7 participants had personal experience of a woman being pregnant at that age. The most commonly used rationales for maximum age were menopause (110) or unlikelihood of pregnancy at that age (26) (Figure 5).

**Method of questioning:** The most common method for determining pregnancy status was the use of verbal questioning (44%), followed by verbal questioning with the addition of the patient’s signature (35%). Only 66 participants (21%) used a written form to ask the patient about their pregnancy status. Assuming the written forms require the patient’s signature, the majority of patients (56%) are asked to verify that they have been questioned about their pregnancy status by providing their signature. Participants were asked to indicate if they used questions regarding last menstrual period (LMP), contraceptive use or menopause/hysterectomy history as part of their routine verbal or written questions. Questions about LMP were most commonly asked (89% if verbal; 93% on written form). Participants using verbal questioning were more likely to ask questions about contraceptive use and menopause or hysterectomy than those that used a written form (Table 1).

**Use of Pregnancy Tests:** Out of 262 responses, 72% indicated that they used pregnancy tests in their department. Serum testing (69%) is most commonly used, with 50% using urine tests. The shared percentages are greater than 100% as some respondents ticked both serum and urine testing. Participants were asked to state in their own words in which circumstances would they use pregnancy tests. The main reason cited for using pregnancy tests was if the patient was unsure or doubtful about their pregnancy status (45%). Other reasons cited were: for therapeutic dose patients, if pregnancy could not be excluded, if the patient had had unprotected sex, if their LMP was late, if there had been more than 10 days since their LMP, if the patient thought they could be pregnant, and if the radiation dose from the procedure was considered high (Figure 6).
Radiation risk to foetus

Participants were asked to rank eight diagnostic nuclear medicine procedures as to their risk to a foetus from ionising radiation with a ranking of 1 being the most risk and a ranking of 8 being the least risk. Only 18/238 (8%) participants correctly ranked all procedures according to foetal dose estimates reported by UNSCEAR (1). However the majority of participant responses were correctly ranked if the procedures were classified by relative risk as:

- High risk (rank 1-3) - 77% correct,
- Medium risk (rank 4,5) - 66% correct, and
- Low risk (rank 6-8) - 75% correct (Table 2).

Table 2 displays the participant rankings for each procedure (ie 171 participants indicated that 18F-FDG PET/CT was the highest risk and 20 participants indicated that it was the lowest risk procedure). The highlighted numbers show the correct ranking for each procedure which was also correctly identified by the majority of participants.

DISCUSSION

Ionising radiation is potentially harmful to a developing foetus. Although diagnostic nuclear medicine procedures use relatively small amounts of radiation, it is still imperative to determine if a patient might be pregnant prior to commencing the procedure. Radiation protection documents such as ICRP 84 (3) and ARPANSA 14.2 (4) provide recommendations regarding the protection of patients undergoing diagnostic nuclear medicine procedures. These documents recommend that all females of child-bearing age should be questioned regarding their pregnancy status prior to administration of any radiopharmaceuticals. They do not, however, give instructions on what constitutes the child-bearing age range, how to question the patient, or when to utilise pregnancy testing.
**Policy and regulations**

This study revealed a very low awareness of government and international regulations concerning pregnancy and medical radiation. The majority of participants reported that they had not read the relevant sections regarding pregnancy and diagnostic procedures in ICRP 84 (3) or ARPANSA 14.2 (4). This correlates with the findings from a previous interview study conducted by the authors (7).

ICRP Publication 84, *Pregnancy and Medical Radiation* (2000) is one of the primary international documents detailing recommendations for the use of ionising radiation in pregnant and potentially pregnant women. Chapter 6 discusses radiation protection applicable to nuclear medicine. It states that for “women of childbearing age, the possibility of pregnancy and the justification for the examination should be considered”. It recommends that patients be “carefully interviewed” to determine their pregnancy status and that “discretion” is required in the case of adolescents. It also states that “advisory notices should be posted” in the nuclear medicine department.

ARPANSA 14.2, *Safety Guide for Radiation Protection in Nuclear Medicine* (2008), was published by the Australian Government to provide advice on radiation practice. Section 5 discusses the protection of the embryo/foetus. It states that: “all female patients of child bearing age” should be questioned regarding their pregnancy status “immediately before the procedure”; the reason for asking should be explained to the patient “to avoid the patient taking offence and not answering fully”; this type of discussion “requires tact and discretion”; asking teenagers may be a “sensitive issue”; an interpreter may be required when language barriers exist; and that patient history alone “may not be reliable”. It lists several circumstances for when the likelihood of pregnancy is very low or physically impossible. These include hysterectomy, tubal ligation, normal menstrual period within the last 10 days (if the patient has regular menstrual periods), taking contraceptive measures (providing it has been taken regularly), and no sexual relationship for several months. If pregnancy status
is uncertain “the nuclear medicine specialist should be consulted” to decide whether to postpone the study, perform a pregnancy test, or continue with the study. This decision may be influenced by the “level of radiation dose” from the procedure.

**Current Practice**

The age range to include for questioning about pregnancy has not been clearly defined. The use of the term “child bearing age” in radiation protection documents refers to any female capable of reproduction. Both the age at menarche and age at menopause are very individual and can vary greatly between females.

The age at menarche is primarily influenced by genetic factors but also by nutrition, geography and altitude (8). In a study investigating age at menarche in 34 countries, Currie (2012) (9) reported that “in 95% of individuals, age at menarche ranged between 10 years 6 months and 14 years 11months”. A number of studies (8, 10, 11) discuss whether there has been a decline in the age of menarche over the past 50 years. Declining age at menarche has been associated with obesity (11). Some studies report a decline in age from 13 to 12 years since the early 20th century but that in the latter part of the century age of menarche appears stable (8, 10). Posner (2006)(10) reports that the “normal range for onset of menarche in the Unites States is now considered 10-14 years”.

The age at natural menopause varies greatly between women. Factors believed to influence age at menopause include ethnicity, location, smoking, body mass index (BMI), physical activity, and number of children (12). A large Australian study of 5961 twin females by Do and Treloar (1998) reported the median age at natural menopause as 51 years (13). Another study of 5288 women by Dratva (2009), conducted in 9 European countries, reported the median age at menopause at 54 years (12). Surgically induced menopause (hysterectomy or tubal ligation) is associated with earlier timing of menopause (12).
Participants in our study reported using age at menarche as the rationale for using a particular minimum age to question patients from 10 years and up to 16 years of age. Age of menopause was used as the rationale for choosing a particular maximum age between 40 and 60 years of age. This implies a lack of knowledge regarding these two aspects of female physiology and reproduction, and possible reliance on personal interpretation and experience. As both menarche and menopause can occur at different ages in individual women, it may be prudent to first ask whether the patient has either begun menstruating for young teenagers, or completed menstruating for women over 50 years of age, or the date of their last menstrual period, rather than beginning with a question asking if they might be pregnant.

Although 65% of participants indicated they had a written department policy for questioning patients, very low numbers stated this as their rationale for the minimum or maximum age to question patients. This may be due to the departmental policies using similar wording to radiation protection documents which refer to “women of childbearing age” but do not define the age range or how to determine who is classed as childbearing. For minimum age many participants commented that selection of patients to question was dependent on the patient’s perceived maturity. This implies that some nuclear medicine personnel make assumptions about the patient when determining pregnancy status.

The American College of Radiologists Practice Guideline for imaging pregnant or potentially pregnant adolescents and women with ionizing radiation (2008) recommends that “all patients of menstrual age (typically ages 12 through 50 years) should be questioned about pregnancy status using a standardized form and/or through direct questioning by the technologist”. It recommends the use of a standardised form to ensure uniformity in the questioning process. (5) Variations in practice can lead to individual patients being treated differently and consequently not receiving the same level of care. Gabel (2004) states that
reducing practice variation is “a fundamental issue for increasing the quality of health care”(14). The development of a standardised form to determine pregnancy status may assist nuclear medicine personnel in ensuring that the appropriate patients are asked appropriate questions. Our study showed a wide variation in the methods used to determine which patients to question and which questions they were asked. Verbal questioning of the patient is still predominately used, with or without the addition of the patient’s signature, and this may be a contributing factor to inconsistencies in practice.

Pregnancy testing is not routinely used prior to diagnostic nuclear medicine imaging procedures. Pregnancy testing all female patients would be unnecessary, time consuming and expensive (7). Urine pregnancy tests are relatively cheap and easy to use however, if used prior to the date of missed menses they have been reported to have a high false-negative rate (15). The most commonly reported circumstance for using pregnancy testing is when the patient is unsure of her pregnancy status. The reliability of patient history and self-assessment of pregnancy status has been reported with conflicting results (16, 17). Minnerop et al (2011)(18) investigated the reliability of patient assessment to exclude pregnancy and found that women are able to exclude pregnancy. They reported a 100% negative predictive value for women stating pregnancy was impossible. They suggest that history of tubal ligation, intrauterine device or oral contraceptive use should not be relied on to exclude pregnancy. Minnerop et al recommends using patient history and suspicion of pregnancy and weighing against the risk associated with undiagnosed pregnancy to decide if a pregnancy test is warranted.

A small number of participants indicated they use pregnancy testing if the radiation dose from a procedure was considered high. This is recommended in ARPANSA 14.2 (4), however a definition of higher dose is not provided. Diagnostic nuclear medicine procedures are generally considered low dose procedures with most $^{99m}$Tc procedures giving an effective dose of less than 10 mSv to an adult patient (1). As the dose is quite low for these
procedures it may be sufficient to rely on patient self-assessment of pregnancy status and to only use pregnancy testing where there is concern or doubt surrounding the patient’s responses. Other procedures that utilise longer lived radioisotopes, positron emission, or hybrid CT imaging may provide a higher effective dose to the patient and therefore would warrant the use of pregnancy testing prior to administration of the radiopharmaceutical.

**Radiation risk to foetus**

Estimation of foetal dose from maternal examinations can be difficult. Calculation of foetal dose estimates must include factors such as the physical properties of the radionuclide, the administered activity, and the stage of foetal development. The chemical and biological properties of the radiopharmaceutical must be taken into account to determine the amount of placental transfer and biodistribution in foetal tissues. External irradiation of the foetus from maternal organs also adds to the dose (19). The foetal doses from most diagnostic nuclear medicine procedures are “much lower than the levels where developmental and neurological effects are known to occur” (4). However, the dose levels have been reported to be associated with “a slightly increased risk of childhood cancer or leukaemia”(4). Although the risks to the foetus are low, anxiety and distress may be caused if a woman is irradiated and subsequently finds out she is pregnant. The participants in this study ranked a number of commonly performed procedures according to their radiation risk to the foetus and although only a small number of participants correctly ranked every procedure, the majority of participants were able to identify the risks as into low, medium and high categories.

**CONCLUSION**

The results of the survey suggest that nuclear medicine personnel in Australia and New Zealand use a variety of methods to determine which female patients to question, and how they are questioned, regarding their pregnancy status prior to diagnostic imaging
procedures. Although there is a lack of knowledge concerning radiation protection guidelines for the protection of the foetus, a good level of knowledge of the relative foetal risk from commonly performed procedures was demonstrated. We recommend that a standardised practice guideline be developed to ensure consistent practice and to reduce the possibility of any unnecessary foetal irradiation.

REFERENCES


FIGURE LEGENDS

Figure 1: Time since participants have read department policy

Figure 2: Open responses for content of regulations
Figure 3: Age of questioning

Figure 4: Rationale for minimum age
Figure 5: Rationale for maximum age

Figure 6: Reported circumstances for using pregnancy tests
### TABLES

#### Table 1: Routine questions

<table>
<thead>
<tr>
<th>Questions</th>
<th>Verbal (n=137)</th>
<th>Written (n=69)</th>
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<tbody>
<tr>
<td>Last Menstrual Period</td>
<td>122 89%</td>
<td>64 93%</td>
</tr>
<tr>
<td>Contraceptive Use</td>
<td>76 55%</td>
<td>28 41%</td>
</tr>
<tr>
<td>Menopause/Hysterectomy</td>
<td>98 72%</td>
<td>36 52%</td>
</tr>
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</table>

#### Table 2: Radiation risk to foetus

<table>
<thead>
<tr>
<th>RELATIVE RISK</th>
<th>PROCEDURE</th>
<th>RANKING Highest risk</th>
<th>Lowest risk</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7 8</td>
<td></td>
</tr>
<tr>
<td>HIGH</td>
<td>18F-FDG PET/CT</td>
<td>171 32 11 6 7 6 3 20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bone scan with SPECT/CT of lumbar spine</td>
<td>37 131 35 18 7 9 14 2</td>
<td></td>
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<tr>
<td></td>
<td>99mTc-Sestamibi Myocardial Perfusion scan</td>
<td>18 49 102 31 21 12 13 5</td>
<td></td>
</tr>
<tr>
<td>MEDIUM</td>
<td>Gated Heart Pool scan</td>
<td>2 9 34 85 73 37 9 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bone scan</td>
<td>1 9 38 81 94 26 4 1</td>
<td></td>
</tr>
<tr>
<td>LOW</td>
<td>Renal Perfusion scan</td>
<td>5 7 23 21 30 105 47 14</td>
<td></td>
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<td>V/Q Lung scan</td>
<td>10 12 4 6 12 37 93 81</td>
<td></td>
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<tr>
<td></td>
<td>99mTc Thyroid scan</td>
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