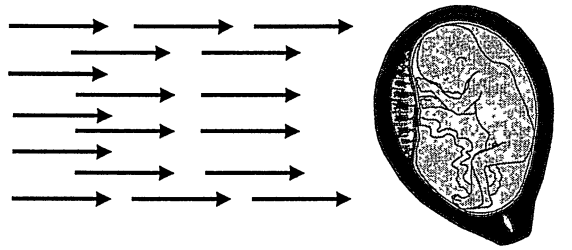
CONCEPTUS RADIATION DOSE AND RISK FROM DIAGNOSTIC X-RAY EXAMINATIONS

J. DAMILAKIS, Assistant Professor of Medical Physics



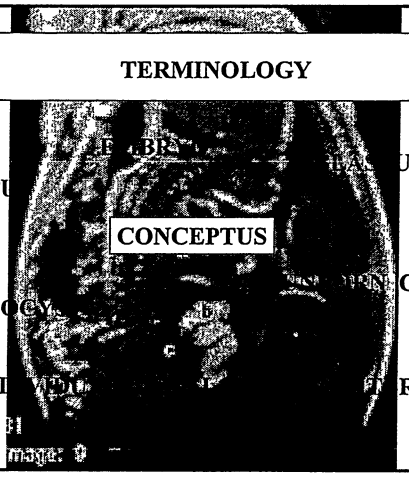
INTENTIONAL EXPOSURES :

EXPOSURES TO PREGNANT WOMEN FOR WHOM X-RAY IMAGING IS CONSIDERED TO BE BENEFICIAL

ACCIDENTAL EXPOSURES :

EXPOSURES TO FEMALE PATIENTS OF CHILDBEARING AGE, WHERE DURING THE FIRST POSTCONCEPTION WEEKS A CONCEPTUS IS IRRADIATED ACCIDENTALLY

TERMINOLOGY

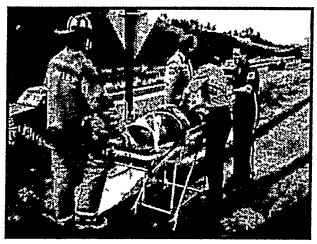


FETU ULA

BLASTO CHILD

INF RO

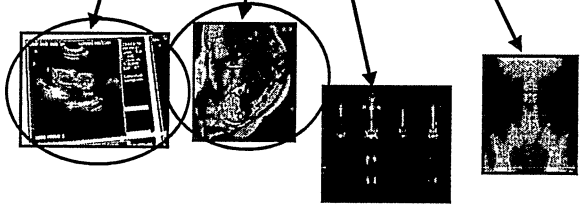
INTENTIONAL EXPOSURES



STEP 1: CONSIDERATION OF ALTERNATIVE METHODS

CONSIDERATION OF AN ALTERNATIVE STUDY

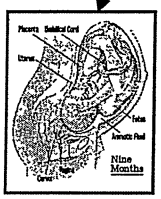
A STUDY INVOLVING LESS RADIATION MAY BE CHOSEN



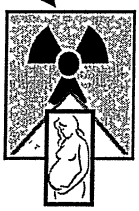
STEP 1: CONSIDERATION OF ALTERNATIVE METHODS

STEP 2: CONCEPTUS RISK EVALUATION

CONCEPTUS RISK EVALUATION



WHAT IS THE CONCEPTION AGE ?



WHAT IS THE ESTIMATED CONCEPTUS DOSE ?

IS A DETAILED DOSE ASSESSMENT ALWAYS NEEDED?

NO IF

- AGE LESS THAN 2 WEEKS
- CONCEPTUS DOSE IS LOW



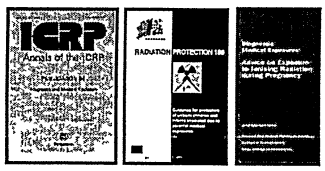
CONCEPTUS DOSE ⟶ mGy

1 10 50 100

INSIGNIFICANT CONCEPTUS DOSE

CONCEPTUS DOSE EVALUATION IS NECESSARY

CONSIDERATION OF ABORTION

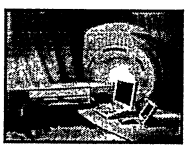


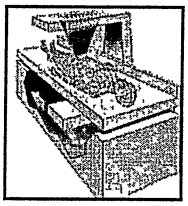
CONCEPTUS DOSE FROM EXTRA-ABDOMINAL X-RAY EXAMINATIONS

EXAMINATIO	CO	DOSE (mGy)
Skull	adiogr	<0.0
Chest	Radiog	<0.0
CT (c		0.(
Card	bation Procedures	

Damilakis et.al. European Radiology 13:406-412, 200
Damilakis et al. Radiation Protection Dosimetry 72:61

CONCEPTUS DOSES FROM CT USED TO DIAGNOSE PULMONARY EMBOLISM





3.3 – 130.8 μGy

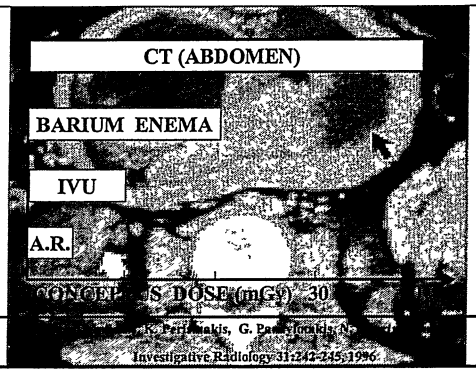
H. Winer-Muram et al. Radiology, 2002

CONCEPTUS DOSES FROM DXA EXAMINATIONS

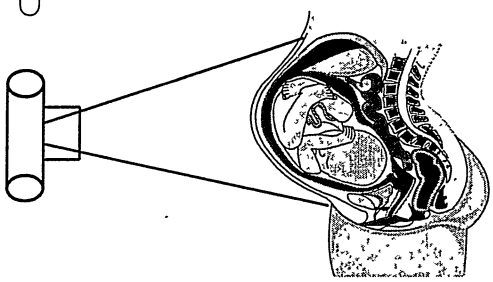
1.6 – 4.9 μGy

J. Damilakis et al. Osteoporos Int, 2002

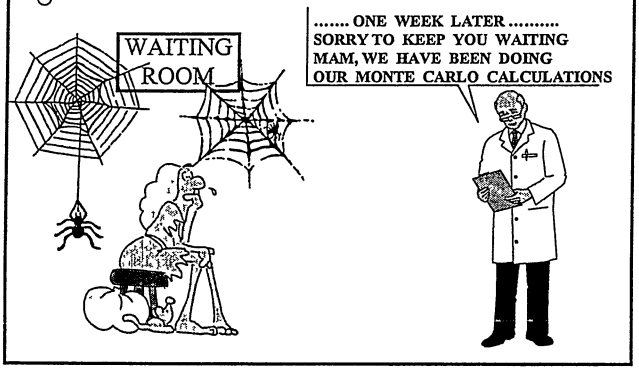
CONCEPTUS DOSE FROM ABDOMINAL X-RAY EXAMINATIONS



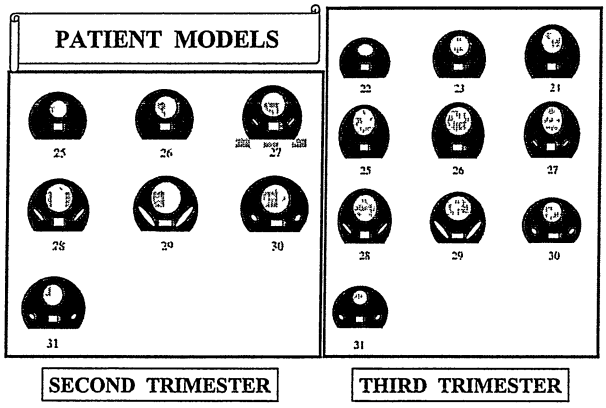
HOW CAN WE ESTIMATE CONCEPTUS DOSE ?



WHICH METHOD ?

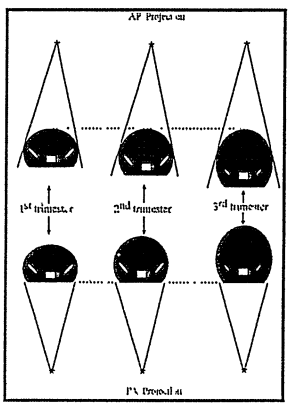


PATIENT MODELS



CONCEPTUS DOSES NORMALIZED TO AIR KERMA FOR AP AND PA ABDOMINAL RADIOGRAPHS

J. Damilakis et al.
Medical Physics
29:2641-48, 2002

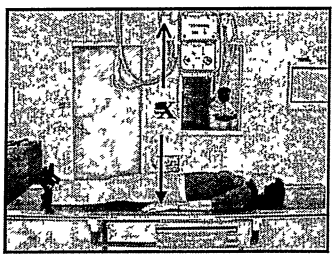


CALCULATIVE METHODS FOR ESTIMATING CONCEPTUS DOSE FROM RADIOGRAPHIC EXAMINATIONS

- Normalized Depth-Dose Technique (Ragozzino et al, 1981)
- Percentage Depth-Dose Technique (Harrison, 1981)
- Tissue-Air Ratio Technique (Schulz and Gignac, 1976)
- Normalized Depth-Dose Estimates (Rosenstein, 1976)

NORMALIZED DEPTH-DOSE TECHNIQUE

- ✓kVp
- ✓HVL
- ✓DISTANCE X



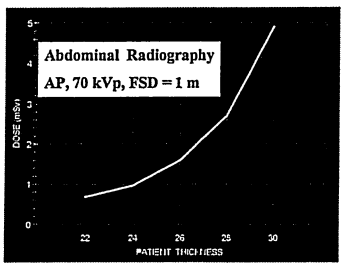
NORMALIZED DEPTH-DOSE TECHNIQUE

kVp

HVL

DISTANCE X

✓PATIENT THICKNESS



NORMALIZED DEPTH-DOSE TECHNIQUE

kVp

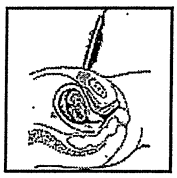
HVL

DISTANCE X

PATIENT AP THICKNESS

✓DEPTH OF CONCEPTUS

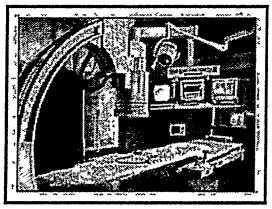
✓FREE IN AIR ENTRANCE EXPOSURE



	Pregnant group Conceptus Depth (cm)	Control group Uterus Depth (cm)
Prevoid	6-10 (8.4)	9.5
Postvoid	4- 8 (5.8)	4.7

K. Perisinakis, J. Damilakis, et al Investigative Radiology 34:449-454, 1999

A METHOD FOR CONCEPTUS DOSE ESTIMATION FROM RF CARDIAC ABLATION PROCEDURES





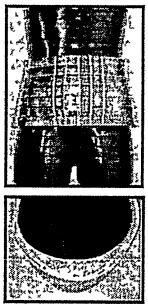
T. Shope, Radiographics, 1996

AVERAGE CONCEPTUS DOSE < 1 mGy

J. Damilakis, N. Theoharopoulos, K. Perisinakis et al

CIRCULATION 104 : 893-897, 2001

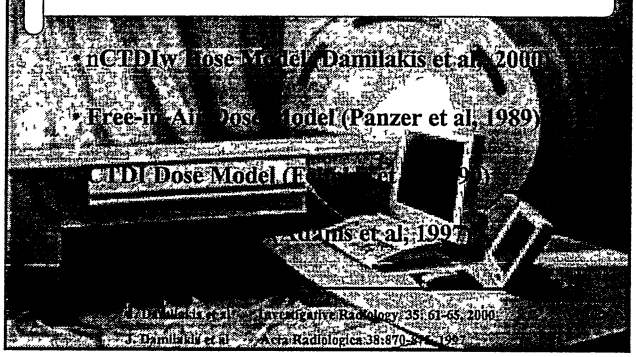
RF CARDIAC ABLATION PROCEDURES



$$D^{j}_{conceptus} = \sum_{i=1}^{4}\left[\left(\frac{O^{*}}{O}\right)_i\left(\frac{mA^{*}}{mA}\right)_i\left(t^{*}\right)_i\left(\frac{SSD}{SSD^{*}}\right)_i^{2} D_i^{j}\right]$$

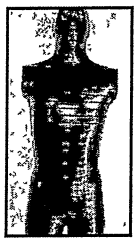
$$D_i^j = \frac{(ESD)_i}{20\cdot 100}\left(\frac{e^b}{(x_2-x_1)}\int_{x_1}^{x_2} e^{ax}\,dx\right)_i^j$$

CALCULATIVE METHODS FOR ESTIMATING CONCEPTUS DOSE FROM CT STUDIES



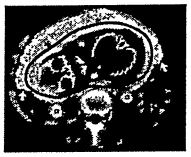
EARLY PREGNANCY: CTDI TECHNIQUE

- kVp
- mAs
- slice thickness and spacing
- Number of slices
- CTDI



LATE PREGNANCY: nCTDIw TECHNIQUE

$$D=\frac{{}_nCTDI_{w1}}{{}_nCTDI_{w2}}\times\frac{\sum_{i=1}^{n} d_i}{n}\times\frac{mAs_1}{mAs_2}$$



$$D=\frac{nCTDIw1}{nCTDIw2}\times\frac{\sum_{i=1}^{n-k} d_i V_i + V_{n-k}\sum_{i=n-k+1}^{n} d_i}{\sum_{i=1}^{n-k} V_i + kV_{n-k}}\times\frac{mAs_1}{mAs_2}$$

BIOLOGICAL EFFECTS OF X-RAYS

➤ STOCHASTIC EFFECTS







CANCER, HEREDITARY EFFECTS

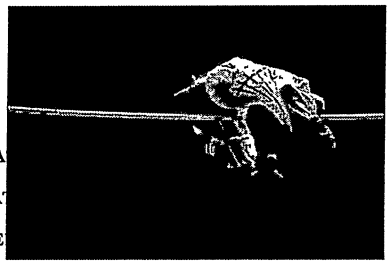
BIOLOGICAL EFFECTS OF X-RAYS

➤ DETERMINISTIC EFFECTS

ORGAN MALFORMA

GROWTH RETARDA

MENTAL IMPAIRME



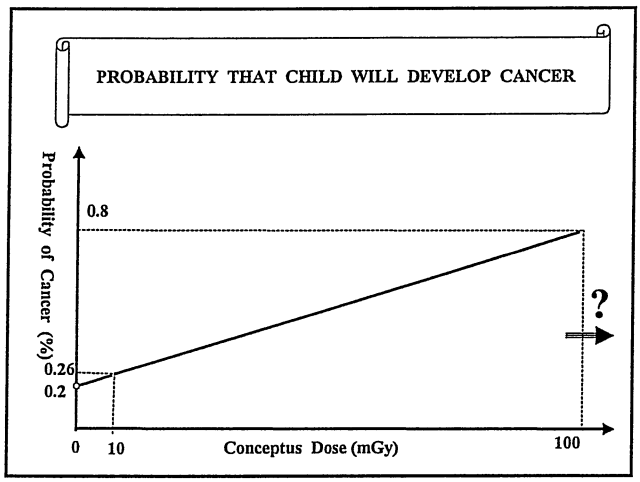
RISK FACTORS

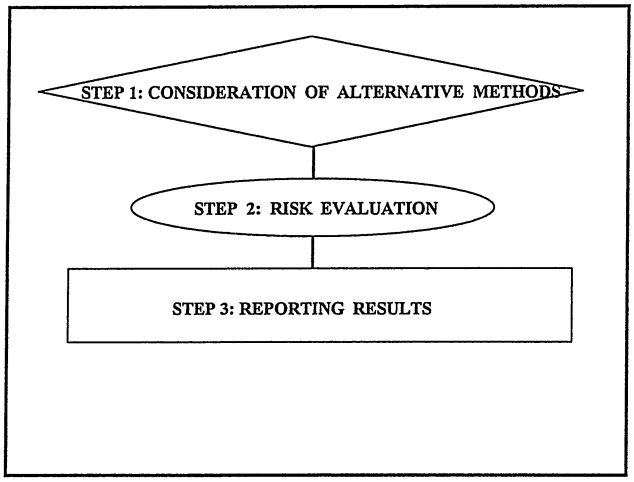
WEEKS POSTCONCEPTION	RESULT	THRESHOLD (Gy^{-1})	RISK
0-2	CONCEPTUS DEATH		
3-8	MALFORMATIONS	0.1	
8-15	MENTAL RETARDATION	0.1	30 IQ points
4-36	CARCINOGENESIS		0.06
0-36	GENETIC EFFECTS		0.01

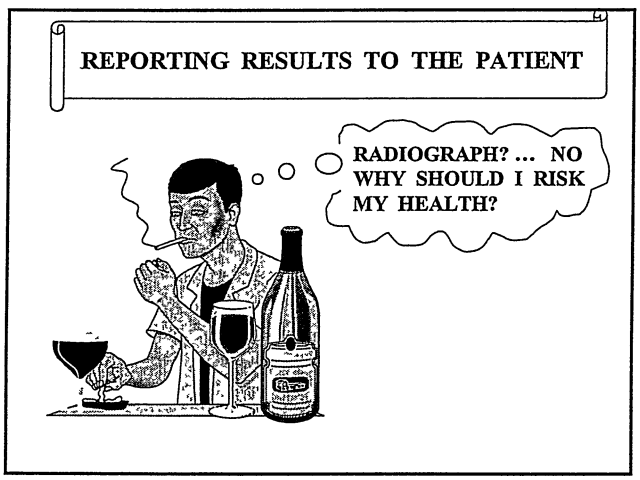
HOW DO WE CALCULATE THE RISK ?

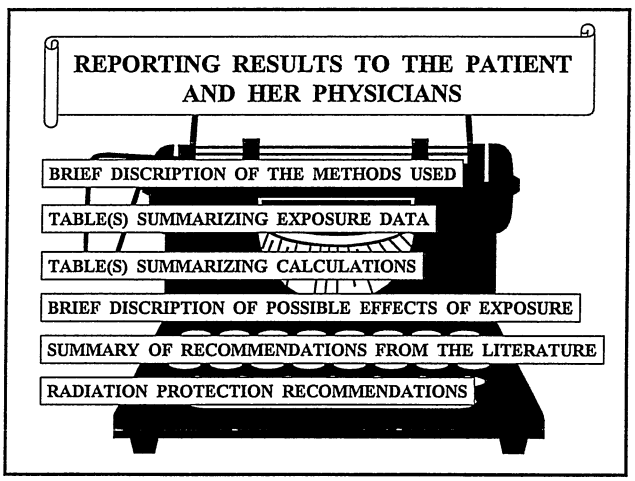
Radiation risk for fatal cancer : 6% per Gy (6% per 1000 mGy)

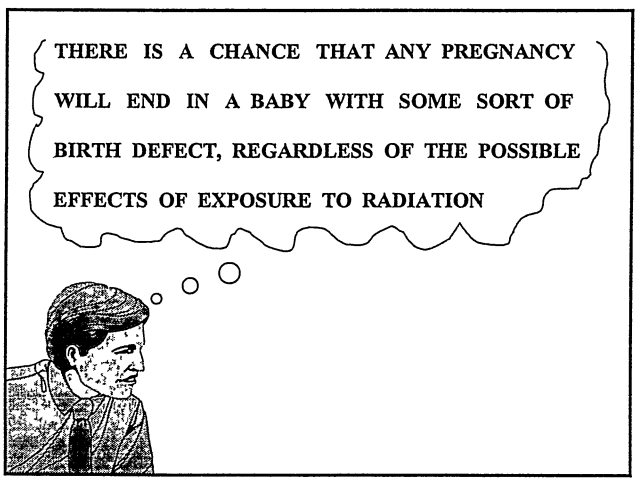
If the conceptus dose from a diagnostic examination is 10 mGy the risk of excess childhood fatal cancer is 0.06%

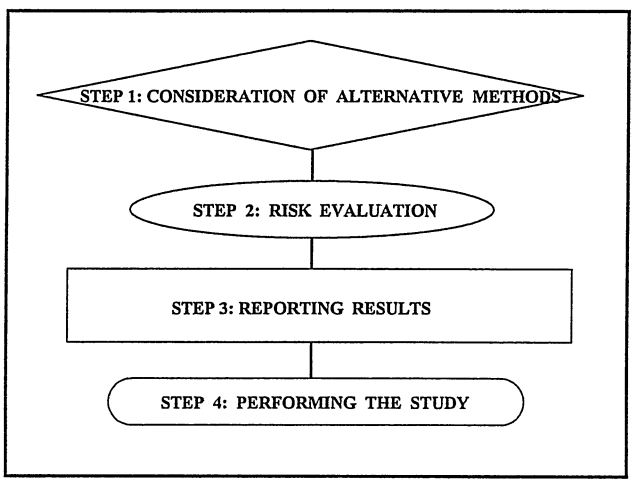

PROBABILITY THAT CHILD WILL DEVELOP CANCER
Probability of Cancer (%)
0.8
0.26
0.2
?
0
10
Conceptus Dose (mGy)
100


STEP 1: CONSIDERATION OF ALTERNATIVE METHODS
STEP 2: RISK EVALUATION
STEP 3: REPORTING RESULTS

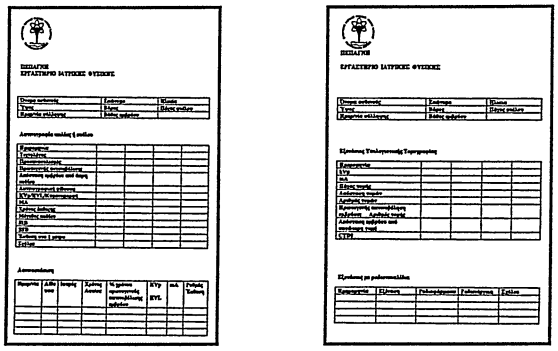

REPORTING RESULTS TO THE PATIENT
RADIOGRAPH? ... NO WHY SHOULD I RISK MY HEALTH?


REPORTING RESULTS TO THE PATIENT AND HER PHYSICIANS
BRIEF DISCRIPTION OF THE METHODS USED
TABLE(S) SUMMARIZING EXPOSURE DATA
TABLE(S) SUMMARIZING CALCULATIONS
BRIEF DISCRIPTION OF POSSIBLE EFFECTS OF EXPOSURE
SUMMARY OF RECOMMENDATIONS FROM THE LITERATURE
RADIATION PROTECTION RECOMMENDATIONS


THERE IS A CHANCE THAT ANY PREGNANCY WILL END IN A BABY WITH SOME SORT OF BIRTH DEFECT, REGARDLESS OF THE POSSIBLE EFFECTS OF EXPOSURE TO RADIATION


STEP 1: CONSIDERATION OF ALTERNATIVE METHODS
STEP 2: RISK EVALUATION
STEP 3: REPORTING RESULTS
STEP 4: PERFORMING THE STUDY

DATA FORMS LISTING NECESSARY INFO TO ESTIMATE CONCEPTUS DOSE



REDUCTION OF CONCEPTUS DOSE

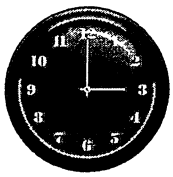
RADIOGRAPHY

- Selection of the most efficient equipment
- Adjustment of the bladder volume
- Careful collimation of the beam
- Use of fast screens and film

REDUCTION OF CONCEPTUS DOSE

FLUOROSCOPY

- Reduction of fluoroscopy time
- Careful collimation of the beam
- Use of fast screens and film



REDUCTION OF CONCEPTUS DOSE

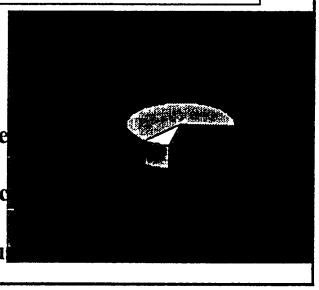
COMPUTED TOMOGRAPHY

- Reduction of mAs
- Reduction of the number of slices
- Non-contiguous slices

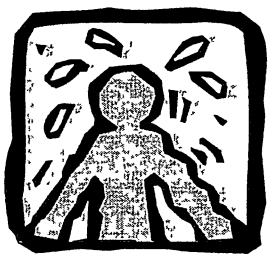
REDUCTION OF CONCEPTUS DOSE

ANGIOGRAPHY/ ABLATION STUDIES

- Insertion of the catheter the subclavian route
- Adjustment of the bladde
- Limitation of the fluorosc
- Shielding of the conceptu



➢ ACCIDENTAL EXPOSURES



SCARE

ACCIDENTAL IRRADIATION
A DIFFERENT CASE

BEFORE THE EXAMINATION
NO PREEXAMINATION ACTIONS

DURING THE EXAMINATION
NO RADIATION PROTECTION MEASURES

AFTER THE EXAMINATION
WE DO NOT KNOW THE EXACT TECHNICAL PARAMETERS
ANXIETY, CONSIDERATION OF ABORTION

HOW CAN WE AVOID ACCIDENTAL IRRADIATION ?

DIRECTIVE 97/43 EURATOM (30/5/97)
Special protection during pregnancy
(Article 10)

- Investigation of the reproductive status of a female of childbearing age prior to x-ray imaging
- If pregnancy cannot be excluded, special attention shall be given to the justification and optimization of the medical exposure

SCREENING FOR PREGNANCY






THOROUGH INVESTIGATION OF THE REPRODUCTIVE STATUS OF A WOMAN



PLEASE INFORM THE STAFF IF YOU THINK YOU MAY BE PREGNANT

MESSAGES TO TAKE HOME

- AVOID ACCIDENTAL IRRADIATION
- AVOID ACCIDENTAL IRRADIATION
- SELECT A STUDY THAT WILL KEEP CONCEPTUS DOSE AT A MINIMUM
- EVALUATE CONCEPTUS DOSE AND RISK FOR ABDOMINAL STUDIES
- BELOW 100 mGy, ABORTION ON THE GROUND OF RADIATION ALONE SHOULD NOT BE CONSIDERED
- PERFORM THE STUDY CONSIDERING ALL RADIATION PROTECTION MEASURES