

Conceptus **D**ose **E**stimation tool

CODE User Manual

http://embryodose.med.uoc.gr/

CODE Manual

Contents

Introduction
Medical exposure of pregnant patients
Module 1: Pregnant patient exposure from radiographic procedures 3
<i>General information</i>
How to use radiography module?4
Module 2: Pregnant patients exposure from fluoroscopic procedures 11
General information
How to use fluoroscopy module?
Module 3: Pregnant patient exposure from computer tomography procedures 20
General information
<i>How to use computed tomography module?</i> 21
Occupational Exposure of Pregnant Employees
Module 4: Occupational exposure from fluoroscopically guided procedures
General information
<i>How to use the occupational exposure module?</i>
References

Introduction

A substantial increase in the use of radiological procedures for pregnant patients has been observed in developed countries over the last decades, while accidental medical exposure of pregnant patients during the first post-conception weeks may occasionally lead to unnecessary pregnancy terminations. Besides, the remarkable increase in the use of fluoroscopically guided interventional procedures observed over the last decades, induced apprehension and concerns regarding the occupational exposure of pregnant employees involved. In either case, the expectant mother has the right to know the level of radiation burden to the embryo from in-utero exposure. Therefore, determination of embryo dose to pregnant patients undergoing radiological procedures and pregnant workers involved in fluoroscopically guided interventional procedures it is of paramount importance.

Code is a web based application which provides reliable estimation of

- a. embryo radiation absorbed dose and radiogenic childhood cancer risk from radiological procedures performed on pregnant patients
- b. embryo radiation absorbed dose from occupational exposure of pregnant employees involved in fluoroscopically-guided interventional procedures.

The current instruction manual provides information on how to use the CODE software. The "General Information" paragraphs describe the methods followed to produce embryo dose data for each module, while "How to use paragraphs describe step by step the operation of CODE software.

Medical exposure of pregnant patients

Module 1: Pregnant patient exposure from radiographic procedures

General information

CODE radiography module provides estimates for the embryo absorbed dose and associated risk for childhood cancer from conventional radiographic projections performed on the pregnant patient.

The Monte-Carlo-N-particle transport code and three mathematical phantoms representing the pregnant individual at 1st, 2nd and 3rd trimester of gestation were employed to produce normalized embryo dose data from common radiographic projections (Table 1) performed on the expectant mother. Embryo dose was normalized to entrance skin dose. Normalized embryo dose (NED) data for each radiographic projection have been produced for several combinations of tube potential and total x-ray tube filtration (Table 1). NED data for the first trimester of gestation were generated for various embryo depths below anterior abdominal surface. In total, more than 7000 Monte Carlo simulations were performed. Based on the derived NED data, fitting equations were produced for the estimation of embryo dose for any tube potential, filtration and embryo depth.

The dose to the embryo (ED) from a series of radiographic projections is calculated from the equation:

$$ED = \sum_{i}^{j} \left\{ \left[\left(\frac{FDD_{O}}{FSD_{X}} \right) \cdot \left(\frac{kV_{X}}{kV_{O}} \right) \right]^{2} \cdot I_{O} \cdot mA \right\}_{i} \cdot NED_{i}$$

where NED_i is the normalized embryo dose for the i radiographic exposure performed and exposure parameters of the examination (tube voltage kV_x , total filtration and focus to skin distance FSD_x). I₀ is the tube output measured at a distance of FDD_o for a tube voltage of kV_o .

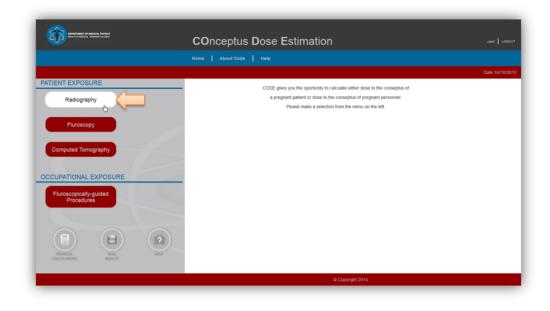
The theoretical radiogenic risk for childhood cancer associated with in-utero exposure is estimated using a risk coefficient of 1.2×10^{-2} per Gy as recommended by the International Commission on Radiological Protection report 90.

Table 1. Radiographic examinations				
Body region under examination	Projections [*]	Field Size (cm ²)	Tube Voltage (kVp)	Filtration (mm Al)
Abdomen	AP	36x43	50-120	2.5-5.0
riodomen	PA	36x43	50-120	2.5-5.0
Chest	AP	36x43	50-120	2.5-5.0
Chiest	PA	36x43	50-120	2.5-5.0
	LAT	36x43	50-120	2.5-5.0
Kidneys	AP	36x24	50-120	2.5-5.0
5	PA	36x24	50-120	2.5-5.0
Lumbar Spine	AP	36x43	50-120	2.5-5.0
×	LAT	36x43	50-120	2.5-5.0
	LAT LSJ	18x24	50-120	2.5-5.0
	LPO	24x30	50-120	2.5-5.0
	RPO	24x30	50-120	2.5-5.0
Pelvis/Colon	AP	36x43	50-120	2.5-5.0
	PA	36x43	50-120	2.5-5.0
	AP Hip Joint	24x35	50-120	2.5-5.0
Thoracic Spine	AP	24x43	50-120	2.5-5.0
	LAT	20x49	50-120	2.5-5.0
Urinary Bladder	AP	24x21	50-120	2.5-5.0

*Note that the angulations of all projections refer to the position of the x-ray tube with respect to the patient body

How to use radiography module?

The user has to select the Radiography module from the menu.

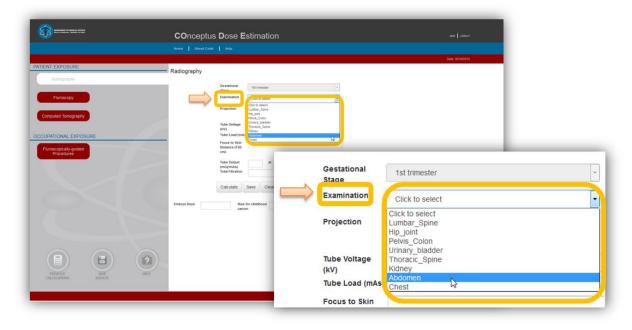


The user has to define/provide the following data regarding the exposure of the pregnant patient for the embryo dose calculation:

 <u>Gestational stage</u>: A pull down menu guides the user to select the gestational stage of the exposed pregnant individual i.e. 1st, 2nd or 3rd trimester.

COncepto	us Dose Estimation	wert LOSOUT	
Home About Co			
PATIENT EXPOSURE		Date 16/10/2015	
Radiography			
Radography	Cestational Cick to welcot		
Computed Tomography	Ded transfer Projection		
OCCUPATIONAL EXPOSURE	Tube Vottage (kV) Tube Load (mAta)		
Fluroscopically-guided Procedures	Focus to Báin Dissue ef 10 cm)		
	Tule Output at XNo FBDo		
	Calculate Save Clear		
Embryo Dose	Risk for childhood cancer		
	Radiography		
PREMOUS SAVE HELP CALCULATIONS RESULTS	Gestational Click to select		-
	Click to select		
	Examination 1st trimester 2nd trimester 3rd trimester		
	Projection Click to Science		

2. <u>Radiographic examination</u>: A pull down menu guides the user to select one of the examinations illustrated in Table 1.



3. P<u>rojection orientation</u>: A pull down menu guides the user to select one of the projections illustrated in Table 1.

		wes 0000/7
	COnceptus Dose Estimation	eed 100007
		Date 16/10/2015
Radiography	Radiography	Date 16/10/2015
Fluroscopy	Gastational tat transform = toge Demonstration Address	
Computed Tomography	Clas to select	
OCCUPATIONAL EXPOSURE	(kr) La Contra C	
Fluroscopcally-guided Procedures	ang Tuko Organ at K00 1500 Toda Fandan	
	Calculate Save Clear	
	Embryo Dose Risk for childhood cancer	
	Projection Click to select	
	Click to select PA	
PREMIUS SAVE HELP CALCULATIONS RESULTS	Tube Voltage AP	
	(kV)	

4. <u>Embryo depth</u>: The user has to define the embryo depth (in cm) i.e. the distance from the anterior abdominal surface of the patient. This field is available only when the user selects 'first trimester' as the gestational stage and an examination associated with direct exposure of the embryo.

	COnceptus Dose Estimation	wes 1.00007
TIENT EXPOSURE		Date 16/10/2015
Radiography	Radiography	
Raulography	Gestational 1st trimester v	
Fluroscopy	Stage Cardination Abdomen	
	Projection Ap	
Computed Tomography	Embryo Depth 9	
	Tube Voltage	
OCCUPATIONAL EXPOSURE	(kV) Tube Load (mAs)	
Fluroscopically-guided Procedures	Focus to Skin	
Procedures	Distance (F50 cm)	
	Table Disbud (molyamika) Todal Filtration	
	Calculate Save Clear	
	Embryo Dose Risk for childhood cancer	
	Embryo Depth	
PREMOUS SAVE HELP	Tube Voltage	
	@ Copyright 2014	

5. <u>Exposure parameters of the examination</u>: The user has to define tube potential (kV), tube load (mAs), and focus to skin distance (FSD (cm) used for the specific radiographic exposure.

COnceptus	s D ose Estimation	
Home About Code		
		Date 16/10/2015
PATIENT EXPOSURE Radiography		
	Gestational 1st trimester ~	
Fluroscopy	Examination Abdomen	
Computed Tomography	Projection Ap	
company remography	Embryo Depth 9	
OCCUPATIONAL EXPOSURE Exposure	Tube Voltage 00 (kV)	
Fluroscopically-guided parameters	Tube Load (mAs) 50 Focus to 5kin 100	
Procedures	cm)	
	Tode odjudt af AND F000	
	Calculate Save Clear	
Embryo Dose	Risk for childhood cancer	
	9	
	Tube Voltage	
	(kV)	
PREMICUS SAVE HELP CALCULATIONS RESULTS	Exposure Tube Load (mAs) 50	
	parameters	
	Focus to Skin	
	Distance (FSD cm)	
	Cm)	

6. <u>Output of the x-ray unit</u>: The user has to provide the output (mGy/mAs) of the x-ray system. The tube voltage and focus to detector distance (FDD_o) used for the output measurement shall be defined in the corresponding fields. The total filtration (mm Al) of the x-ray tube used for the radiographic examination and the measurement of the output should be the same and should be defined in the relevant field.

	Dose Estimation	met unov
Kome About Code		
PATIENT EXPOSURE		Date 16/10/2015
Radiography		
Radoptady Functional Computed Tempstrady COCUMATIONAL EXPOSURE Proceedings Proceedings	State State 12 Productor • State • • Addamese • • Projection • • Addamese • • Projection • • Addamese • • Addamese	
Embryo Dose	Blak for childhood cancer	
		at kVo 80 FDDo 100

When all the necessary data has been supplied, the embryo dose and the corresponding theoretical radiogenic risk for childhood cancer are calculated by pressing the <Calculate> button and presented in the corresponding fields.

		Dose Estimation		
TIENT EXPOSURE			Date 16/1	/2015
Radiography	Radiography			
(isosypophy		Gestational 1st trimester v		
Fluroscopy		Examination Abdomen		
		Projection AP		
Computed Tomography		Embryo Depth 9		
CUPATIONAL EXPOSURE		Tube Voltage 00 (kV)		
		Tube Load (mAs) 50		
Fluroscopically-guided Procedures		Focus to Skin Distance (FSD		
		cm) Tube Output 1.02 at kVo 80 F000 100		
		Tube Output (mGyimAs) 1.02 at kVo 80 F00o 100 Total Fitration 4		
		Calculate lave Clear		
	mbryo Dose 20.568 r	Oy Risk for childhood 0.25%		
		cancer Caro		
	Embryo Dose (mG 0 mGy	Probability of no mailformation (%) Probability of no cancer (0-19y) (%) 97 99.7		
	20.568 mGy	97 99.6976		
		5		
		Calculate Save	Clear	
PREMOUS SAVE HELP CALOULATIONS RESULTS		- the second second	olou.	
		Embryo Dose 32.906 mGy	Risk for childhood 0.39%	
		32.906 mGy	cancer 0.39%	
			Probability of no malformation (%)	
		0 mGy	97	99.7
		32.906 mGy	97	99.6961

Using the <Save Results> button, the registered user can also save a calculation, including all exposure data and date and time of submission for later revision.

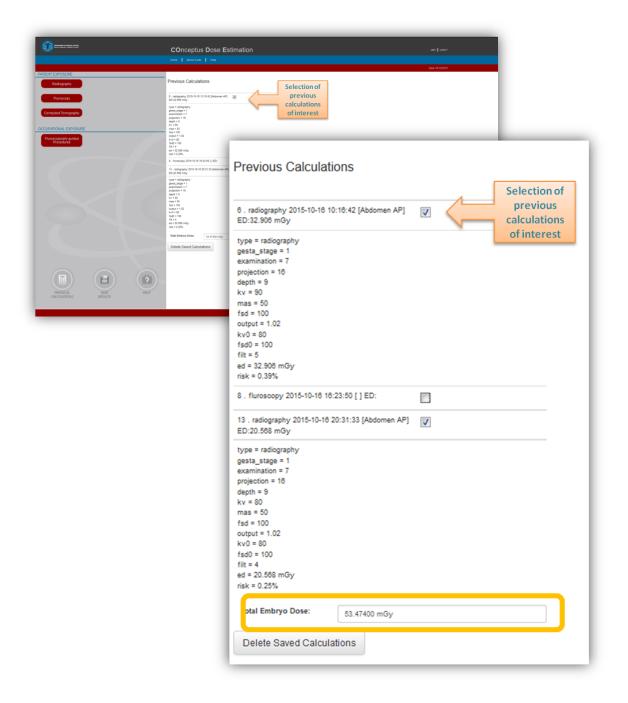
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		Date 16/15/2015
PATIENT EXPOSURE Radiography	Radiography	
Fluroscopy	Grastional tal timester Stage Automation Automation	
Computed Tomography	Prejector AP	
OCCUPATIONAL EXPOSURE Funoscopicallyguided Procedures	Table Voltage 60 (b0) 50 Table Load (Indua) 50 Forevant Stables 100	
	Entryo Dese	Ļ
	Endory Davie (HO)1 Probability of no mathematics (N) Probability of a 1 mOy 22 20 ABM mOy 32 20 Color utlette	Clear
RENDS CALCULARINS RESULTS	Calculate	Save Clear
	@ Capyriph 2014	

• The user can clear the form and start over a new calculation using the <Clear> button.

	COnceptus Dose Estimation	wet 1050/T
		Date 16/10/2015
PATIENT EXPOSURE	Radiography	
Radiography	Gestational tast trinester	
Fluroscopy	Stage Examination Abdonen	
	Projection AP	
Computed Tomography	Embryo Depth 9	
OCCUPATIONAL EXPOSURE	Tube Voltage 80	
	Tube Load (mAs) 50	
Fluroscopically-guided Procedures	Focus to Skin Distance (F50 om)	
	Total independ to the table to the table t	
	Calculate Save Dear	
	Embryo Dose 20.568 x0y Risk for childhood 0.25% cancer	
	Embryo Bose (mGy) Probability of no maiformation (%) Probability of no cancer (0-19y) (%) 0 mGy 97 99.7	
	20.660 mGy 97 99.6975	
	Calculate Sa	ve Clear

Additionaly, the user has the oppurtunity to calculate the cumulative embryo dose from several exposures for which calculation of embryo dose has been performed and saved. The user has to press <Previous Calculations> button and select the specific exposures. The cumulative embryo dose from the selected exposures is then calculated and presented.

	COnceptus Dose Estimation	wet 0 1000/T
		Date 16/10/2015
PATIENT EXPOSURE Radiography	Radiography	
	Gestational tst trimester w	
Fluroscopy	Examination Abdomen	
	Projection	
Computed Tomography	Embryo Depth 9	
OCCUPATIONAL EXPOSURE	Tube Voltage 80 (4V)	
Flurasconicality outdad	Tube Load (mAs) 50	
Fluroscopically-guided Procedures	Focus to Skin Distance (f 50 cm)	
	Made Damping 110 at KNO 100 100 Total Threadow 4 Carculatie Same Clear Endryn Bers 25 500 mOy Bin for childhood 120%.	
	Embryo Dose (mGy) Probability of no malformation (%) Probability of no cancer (0-19y) (%) 0 mGy 97 99.7	
	0 may 27 22, 7 28,660 mGy 97 99,0075	
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Return to HELP

Module 2: Pregnant patients exposure from fluoroscopic procedures

General information

CODE fluoroscopy module provides estimates for the embryo absorbed dose and associated risk for childhood cancer from fluoroscopically guided (FG) procedures performed on the pregnant patient.

The Monte-Carlo-N-particle transport code and three mathematical phantoms representing the pregnant individual at 1st, 2nd and 3rd trimester of gestation were employed to produce normalized embryo dose data from common fluoroscopic projections involved in FG procedures (Table 2) performed on the expectant mother. Embryo dose was normalized to dose area product (DAP). Normalized embryo dose (NED) data for each fluoroscopic projection have been produced for several combinations of tube potential and total x-ray tube filtration (Table 1). NED data for the first trimester of gestation were generated for various embryo depths below anterior abdominal surface. Based on the derived NED data, fitting equations were produced for the estimation of embryo dose for any tube potential, filtration and embryo depth.

The dose to the embryo (ED) from a series of fluoroscopic projections is calculated from the equation:

$$ED = \sum_{i}^{n} (DAP_i \cdot NED_i)$$

where DAP_i is the DAP recorded for the projection i performed at a specific tube voltage, total filtration and focus to skin distance, and NEDi is the normalized to DAP embryo dose for the i fluoroscopic projection and the same exposure parameters

The theoretical radiogenic risk for childhood cancer associated with in-utero exposure is estimated using a risk coefficient of 1.2×10^{-2} per Gy as recommended by the International Commission on Radiological Protection report 90.

Procedure	Projection*	Field size	Tube	Total
Tiocedure	rojection	(cm^2)	Voltage	Filtration
		(em)	(kVp)	(mm Al)
Barium Enema	AP Colon/Pelvis	24x30	50-120	2.5-9.0
Darium Enema	AP Colon/Pervis AP Rectum	24x30 15x15	50-120 50-120	2.3-9.0
	LAO Colon	35x35	50-120	2.5-9.0
	LAO Elion	28x35	50-120	2.5-9.0
	LAO Flexule LAT Rectum	28x33 17x17	50-120 50-120	2.5-9.0
	LAT Rectum LPO Colon		50-120 50-120	2.5-9.0
		35x35		
	LPO Rectum	19x19	50-120	2.5-9.0
	PA Pelvis/Colon	40x40	50-120	2.5-9.0
	PA Rectum	15x15	50-120	2.5-9.0
	RAO Colon	35x35	50-120	2.5-9.0
	RAO Flexure	28x35	50-120	2.5-9.0
	RAO Rectum	19x19	50-120	2.5-9.0
Barium Follow Through	AP Small Intestine	22x18	50-120	2.5-9.0
	PA Small Intestine	22x18	50-120	2.5-9.0
Barium Meal	AP Duodenum	15x15	50-120	2.5-9.0
	AP Stomach	18x22	50-120	2.5-9.0
	AP Upper Stomach	15x15	50-120	2.5-9.0
	LAO Stomach	21x21	50-120	2.5-9.0
	LAT Stomach	19x24	50-120	2.5-9.0
	LPO Duodenum	19x19	50-120	2.5-9.0
	LPO Stomach	21x21	50-120	2.5-9.0
	PA Duodenum	15x15	50-120	2.5-9.0
	PA Stomach	18x21	50-120	2.5-9.0
	PA Upper Stomach	15x15	50-120	2.5-9.0
	RAO Duodenum	19x19	50-120	2.5-9.0
	RAO Stomach	21x21	50-120	2.5-9.0
Barium Swallow	LAO Oesophagus	13x47	50-120	2.5-9.0
	LAT Throat	18x24	50-120	2.5-9.0
	LPO Oesophagus	13x47	50-120	2.5-9.0
	RAO Oesophagus	13x47	50-120	2.5-9.0

*Note that the angulations of all projections refer to the position of the tube with respect to the patient body.

Table 2B.	Cardiac fluoroscop	pically guide	d procedure	2S
Procedures	Projection*	Field size (cm ²)	Tube Voltage (kVp)	Total Filtration (mm Al)
Coronary Angiography/	PA	12.5x12.5	70-100	3-13
Angioplasty	PA CRANIAL 30	12.5x12.5	70-100	3-13
	PA CAUDAL 30	12.5x12.5	70-100	3-13
	LLAT	12.5x12.5	70-100	3-13
	RAO 30	12.5x12.5	70-100	3-13
	LAO 40	12.5x12.5	70-100	3-13
	LAO45 CRANIAL 20	12.5x12.5	70-100	3-13
	RAO 20 CRANIAL 20	12.5x12.5	70-100	3-13
	RAO 20 CAUDAL 20	12.5x12.5	70-100	3-13
	LAO 40 CAUDAL 30	12.5x12.5	70-100	3-13
Pacemaker Implantation	PA	12.5x12.5	50-120	2.5-9.0
	RAO 30	14x14	50-120	2.5-9.0
	LAO30	14x14	50-120	2.5-9.0
Cardiac Ablation	AP	12.5x12.5	50-120	2.5-9.0
	LAO 30	14x14	50-120	2.5-9.0
	RAO 30	14x14	50-120	2.5-9.0
	Guidance iliac	6x6	70-100	3-13
	Guidance jugular	6x6	70-100	3-13

*Note that the angulations of all projections refer to the position of the image intensifier with respect to the patient body.

Table 2C.	Orthopedic fluorosc	copically guid	led procedu	res
Procedures	Projection*	Field size (cm ²)	Tube Voltage (kVp)	Total Filtration (mm Al)
Femoral Fractures	Hip joint LAT	15x15	70-100	3-13
	Hip joint PA	15x15	70-100	3-13
Kyphoplasty	AP Lumbar Spine	8x15	70-100	3-13
	LAT Lumbar Spine	8x15	70-100	3-13

*Note that the angulations of all projections refer to the position of the image intensifier with respect to the patient body.

Table 2D:	Other fluoroscopic	ally guided	procedures	
Procedures	Projection*	Field size (cm ²)	Tube Voltage (kVp)	Total Filtration (mm Al)
Endoscopic retrograde cholangio- pangratography(ERCP)	LLAT Abdomen	20x20	80-100	2.5-9.0
Inferior Vena Cava filter	Guidance iliac	6x6	70-100	3-13
placement	Guidance jugular	6x6	70-100	3-13
	Suprenal placement	15x8	80-100	3-13
	Subrenal Placement	15x8	80-100	3-13
Cysteourethrography	AP ^T Bladder	24x21	50-120	2.5-9.0
Prophylactic	PA ^T Left artery	18x22.5	80-100	3-13
hypogastric artery balloon	PA ^T Right artery	18x22.5	80-100	3-13
occlusion (HABO)***	RA 20 Left artery	18x22.5	80-100	3-13
	RAO 20 Righ artery	18x22.5	80-100	3-13
	LAO 20 left artery	18x22.5	80-100	3-13
	LAO 20 Right artery	18x22.5	80-100	3-13

^{*}Note that the angulations of all projections refer to the position of the image intensifier with respect to patient body.

^T The angulation of these projections refers to the position of the tube with respect to patient body.

^{**}NED data for HABO procedures have been produced only for the 3rd trimester of gestation, since this procedure is performed in parturient women.

How to use fluoroscopy module?

The user has to select the fluoroscopy module from the menu.

	COnceptus Dose Estimation
	Home About Code Help
	Date 16/10/2015
PATIENT EXPOSURE Radiography	CODE gives you the oportunity to calculate either dose to the conseptus of a pregnant patient or dose to the conseptus of pregnant personnel. Please make a selection from the menu on the left.
Fluroscopy	
Computed Tomography OCCUPATIONAL EXPOSURE	
Fluroscopically-guided Procedures	
PERSON OCICIALMENTS CALCALAMENTS HAT HAT	
	© Copyright 2014

The user has to define/provide the following data regarding the exposure of the pregnant patient for the embryo dose calculation:

1. <u>Gestational Stage:</u> A pull down menu guides the user to select the gestational stage of the exposed pregnant individual i.e. 1st, 2nd or 3rd trimester.

	COnceptus Dose Estimation	NH12 L000UT
PATIENT EXPOSURE Radiography Fluroscopy Computed Tomography OCCUPATIONAL EXPOSURE Fluroscopically-guided Procedures	Fluroscopy (estational Stage) Save Clear Save	Date 10/10/2015
	Copyright 2014	

2. <u>Fluoroscopic procedure or projection</u>: The user has the opportunity to select either a single fluoroscopic projection

	COnceptus	Dose Estimat	ion	user2 LO	юлт
				Date 16/10/	2015
PATIENT EXPOSURE Radiography	Fluroscopy				
Radiography	Gestational Stage	1st trimester v	Clear		
Fluroscopy		c Procedures			
Computed Tomography region	Esophagus LAO	Lower Abdomen_Pelvis	Esophagus RAO	E Heart LAO 40	E Heart LAO 40-CAU 30
OCCUPATIONAL EXPOSURE	E Heart LLAT	Heart PA	Heart PA-CAU 30	Heart PA-CRA 30	Heart RAO 20-CAU 20
Fluroscopically-guided Procedures	Heart RAO 20-CRA 20	E Heart RAO 30			
	Save		Fluoroscopic projections per		
PRODUCT BOARD BARRIER			Body region		
			© Copyright 2014		

or a series of projections commonly used during a common FG procedure (Tables 2A, 2B, 2C and 2D). In each case a menu guides the user to select the body region imaged and one of the projections illustrated in Tables 2A, 2B, 2C and 2D.

	COnceptus Dose Estimatio	n	55672 LOGOUT	
			Date 16/10/2015	
PATIENT EXPOSURE Radiography	Fluroscopy Gestational Stage	Clear		
Fluroscopy Computed Tomography	Arrangee propting Arrangee Researce Sectorearray Conners Angregate Conners Angregate Conners Angregate These LAO 46-CAU 30 Heart PA-CRA 30		E Heart LAO 40	Heart PA-CAU 30
OCCUPATIONAL EXPOSURE	Heart RAO 30 Heart PA	Heart RAO 20-CRA 20	E Heart LLAT	E Heart RAO 20-CAU 2
		Fluoroscopic projections per Body region		
	¢	Copyright 2014		

3. <u>Embryo depth:</u> The user has to define the embryo depth (in cm) i.e. the distance from the anterior abdominal surface of the patient. This field is available only when the user selects 'first trimester' as the gestational stage and a projection associated with direct exposure of the embryo.

	COnceptus Dose Estimation	wert LOSOUT
		Date 16/10/2015
PATIENT EXPOSURE	Fluroscopy	
Radiography	Gestational Stage stationester * Cloar Unlock	
Fluroscopy	Pursespit projektives Farmanije Frankrives	
Computed Tomography Pelvis AP irradiates	Thirds (real) Loper Address (real)	
Computed Tomography Pelvis AP irradiates embryo, primarily	Petris AP Petris PA Colon AP Colon LAO Colon LPO	
OCCUPATIONAL EXPOSURE	Colon RAO Rectum AP Rectum LAT Rectum LPO	
Eluraes apically, auided	Rectum PA Rectum RAO Urinary, Bladder AP	
Fluroscopically-guided Procedures		
	Lower Abdomen_Pelvis - Pelvis AP Remove	
	Embryo depth(cm)	
	Lube Voltage Dose Area Product(Cycm ³)	
	FSD (cm)	
	Filtration (mm Al) ♥ (mm cu) →	
	Calculate Save Clear	
PREMOUS SAVE HELP CALCULATIONS RESULTS		
	@ Copyright 2014	

4. <u>Exposure parameters of the examination:</u> The user has to define tube potential (kVp), tube inherent and added filtration (mm Al/mm Cu), focus to skin distance FSD (cm), and DAP used for the specific fluoroscopic projection.

	COnceptus Dose Estimation	unt 18917
		Darle 16/10/2015
	Fluroscopy	
Radiography	Gestational Rage v Clear Unlock	
Fluroscopy		
	Nanada pentras Nanjust Ger Alamet, Laer Assemption	-
Computed Tomography	Thevia AP Thevia NA Totes AP Totes LAO Totes LPO	
OCCUPATIONAL EXPOSURE	Colon RA Electure AP Electure LAT Electure LPD	
Fluroscopically-guided Procedures	Peter N. Peter NO Concy, Batter A*	
Exposure parameters for Pevily PA projection Exposure parameters for Colon RAO projection	Lover Addomer, Petris - Fabris AP Remove Stand making Sta	
TRUESS MARKET INTO INC.		
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 When all the necessary data has been supplied, the embryo dose and the corresponding theoretical radiogenic risk for childhood cancer are calculated by pressing the <Calculate> button and presented in the corresponding fields.

•	
	COnceptus Dose Estimation
	www.l.mastan.l.ma
PATIENT EXPOSURE Radiography	Fluroscopy
Personal	Author Ray W HINNE V Case Union
Computed Tomography	
	Rear Leave L
OCCUPATIONAL EXPOSURE	Provide Parties Parties P
Proceeding	Lower Abdomen_Pehris - Pehris AP Remove
	Network Methods 1
	Start And Andread Start Star
	700m
	Lower Abdomen_Pelvis - Colon RAO Renove
	San Lan Mandaligue) 4
	Tenin max 0 max
	Caluar Size Dear
	Results
	Projection Dose
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	terr, Asem, Yon, Con, Kal. Kall within 12
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	Results
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	Lower_Abdomen_Pelvis_Colon_RAO \$3.\$1 mGy
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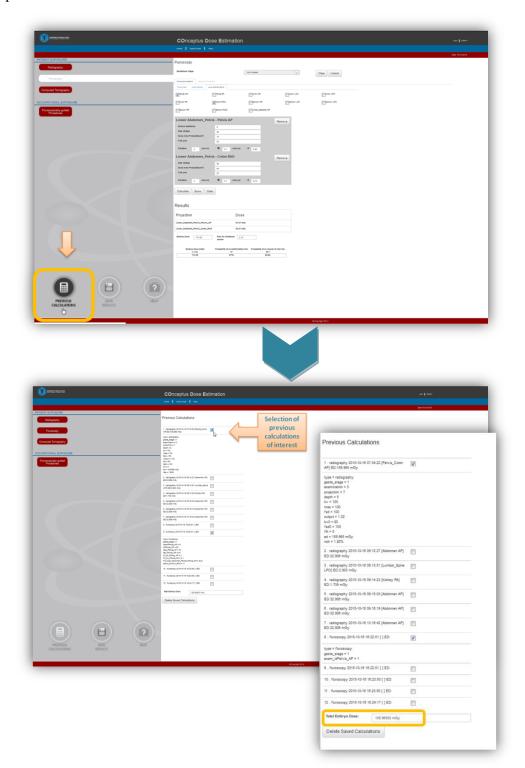
 Using the <Save> button, the user can also save a calculation, including all exposure data and date and time of submission for later revision.

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PROBAS GACUARDAN SALE	Baugite

Additionaly, the user has the oppurtunity to calculate the cumulative embryo dose from several exposures for which calculation of embryo dose has been performed and saved. The user has to press <Previous Calculations> button and select the specific exposures. The cumulative embryo dose from the selected exposures is then calculated and presented.



Return to HELP

<u>Module 3</u>: Pregnant patient exposure from computer tomography procedures

General information

CODE CT module provides estimates for the embryo absorbed dose and associated risk for childhood cancer from computed tomography examinations of the trunk performed on the pregnant patient.

Normalized to free in air computed tomography dose index (CTDI) embryo dose coefficients (f(z)) for single sequential scans at different positions along z-axis to cover the whole trunk of the pregnant individual were produced through Monte Carlo simulation experiments. The Monte-Carlo-N-particle transport code and four mathematical phantoms representing the average pregnant individual at first post-conception weeks (0-7 weeks), 1st trimester (8-12 weeks), 2nd trimester (13-25 weeks) and 3rd trimester (26-40 weeks) of gestation were employed. Phantoms were generated by using the Body Builder software and the abdominal circumference of these phantoms representing the average pregnant individual during first post-conception weeks and 1st trimester, the embryo depth (i.e. the distance from anterior abdominal surface) was assumed 9 cm. Dosimetric data were derived for a Siemens Sensation 16 CT scanner. Further details on the methodology used to derive the normalized embryo dose data can be found elsewhere (Damilakis et al Med Phys 2010).

The embryo dose (ED) from a specific CT exposure performed on a pregnant patient is estimated using the formula

$$ED = CTDI_F \cdot NCD_{p_0} \cdot f_{p,d} \cdot f_{scanner}$$
(1)

where

- a. $CTDI_F$ is the free-in-air CTDI (mGy) of the user's CT scanner for the tube voltage, tube load and beam collimation employed,
- b. NED_{po} is the cumulative normalized embryo dose for the specific boundaries of the scanned body region modified for the beam collimation and pitch used for the examination as calculated from:

$$NCD_{p_0} = \frac{20mm}{BC(mm)} \cdot \frac{1}{pitch} \cdot \sum_{z_1}^{z_2} f_z(\frac{mGy}{mGy_{air}})$$
(2)

where p_0 is the abdominal circumference of the average pregnant individual at the gestational stage of the examined pregnant patient.

- c. $f_{p,d}$ is the correction factor for embryo depth d and abdominal circumference p
- d. f_{scanner} is the correction factor for the specific scanner used for the examination

Further details on embryo dose calculation may be found in previous publications (Damilakis et al Med Phys 2010, and Damilakis et al Radiology 2010).

How to use computed tomography module?

The user has to select the fluoroscopy module from the menu.

DOMESTICAL POTICIAL	COnceptus Dose Estimation
	Home About Code Help
	Date 18/10/2015
PATIENT EXPOSURE Radiography	CODE gives you the oportunity to calculate either dose to the conseptus of a prognant patient or dose to the conseptus of prognant personnel. Please make a selection from the menu on the left.
Fluroscopy	
OCCUPATIONAL EXPOSURE	
Fluroscopically-guided Procedures	
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	© Copyright 2014

The user has to define/provide the following data regarding the exposure of the pregnant patient for the embryo dose calculation:

1. <u>Gestational stage</u>: A pull down menu guides the user to select the gestational stage of the exposed pregnant individual i.e. 0-7 weeks, 8-12 weeks, 13-25 weeks, and 26-40 weeks.

POPURATION OF MIDDAL POPURATION	COnceptus Dose Estimation	UNER2 LOGOUT
	Home About Code Help	
		Date 16/10/2015
Radiography	Computed Tomography (CT) Please select a gestational stage:	
Fluroscopy	Prese velect gestational stage: 0-7 week	
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Fluroscopically-guided Procedures		
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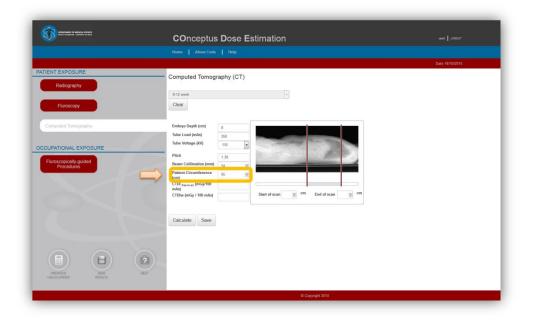
2. <u>Embryo depth:</u> The user has to define the embryo depth (cm) i.e. the distance from the anterior abdominal surface of the patient. This field is available only when the user has selected the first postconception weeks (0-7 weeks) or the first trimester of gestation (8-12 weeks).

	COnceptus Dose Estimation	
		Date 16/10/2015
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Fluroscopy Computed Tomography COCUPATIONAL EXPOSURE Fluroscopically-guided Proceduly-guided	Entrayo Depth (cn) s Une Votage (xiv) Cit: At to define Prote Beam Collimation (mm) 8	
	Calculate Save	

3. <u>Exposure parameters of the examination:</u> The user has to define from pull down menus the tube potential (kV) and the beam collimation used during the examination. Also, the tube load (mAs), and the pitch of the examination has to be defined in the relevant fields.

	COnceptus Dose Estimation	wet LODOUT
PATIENT EXPOSURE	Home About Code Holp	Date 16/10/2015
Radiography	Computed Tomography (CT) B12 rest: Clear	
Functory Computed Teanography OCCUPATIONAL EXPOSURE Functional exposure Proceedures	Embro Deck (cm) 0 Tube Voltage (kY) 10 100 Tube Voltage (kY) 100 100 Pach 130 120 Dear Collination (mm) 24 120 Other Collination (mm) 24 120 Citik resource (mGy100 24 120 Citik resource (mGy100 24 120 Citik resource (mGy100 24 120 Citik resource (mGy1100 24 120 Citik resource (mGy1100 24 120 Citik resource (mGy1100 24 120 Start of scan 20 60 End of scan	
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4. <u>Patient circumference</u>: The user has to define the abdominal maternal circumference in cm.



5. <u>CTDI_{free in air} and CTDI_w:</u> The user has to provide the CTDI_{free in air} and CTDI_w (mGy/100 mAs) of the scanner used, at the same kV and beam collimation (mm) set for the patient examination.

	COnceptus Dose Estimation	
TIENT EXPOSURE Radiography Fluroscopy	Computed Tomography (CT) 5-12 week Clear	Date 16/18/2015
Conputed Tomography CUPATIONAL EXPOSURE Fluroscopically guided Procedures	Embryo Depth (on) 6 Tube Load (mAi) 350 Tube Voltage (kV) 110 9 Pitch 24 10 Patient Cicumference 56 10	
	Calculate Save	
	© Copyright 2014	

6. <u>Body region scanned:</u> The user has to define the boundaries of the scanned volume (the start and the end of the scan) moving appropriately the cursors at the corresponding anatomical locations on the provided trunk topogram.

PATIENT EXPOSURE Radiography Fairoscopy	COnceptus Dose Estimation New About Code Help Computed Tomography (CT) The cursors dete and the end	
Conputed Temography OCCUPATIONAL EXPOSURE Fursacopically-guided Procedures	Embryo Depth (cm) Tube Load (mAd) Tube Voltage (KV) Place Beam Collination (nm) Pdata Beam Collination (nm) Pdata Beam Collination (nm) Pdata Beam Collination (nm) Pdata Collination (nm) Pdata Sist of acam .10 0 cm End of acam 12 0 cm Calculate Save	
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When all the necessary data has been supplied, the embryo dose and the corresponding theoretical radiogenic risk for childhood cancer are calculated by pressing the <Calculate> button and presented in the corresponding fields.

	COnceptus Dose Estimation		wes 1 kosout
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	8-12 wres		
Fluroscopy	Clear		
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	Tube Load (mAs) 359 Tube Voltage (kV) 410		
PATIONAL EXPOSURE			
roscopically-guided Procedures	Pitch 1.30 Beam Collimation (mm) 24		
Procedures	Patient Circumference		
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	CTDfw (mGy / 100 mAs) 8.3 Start of scan -10 🔮	cm End of scan 12 🔯 cm	
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	Calculate Save		
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	Embryo Dose (mGy) 0 mGy	Probability of no malformation (%) 97	Probability of no cancer (0-19y) (99.7
	23.621 mGy	97	99.697

Using the <Save Results> button, the registered user can also save a calculation, including all exposure data and date and time of submission for later revision

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Additionaly, the user has the oppurtunity to calculate the cumulative embryo dose.from several CT exposures for which calculation of embryo dose has been performed and saved. The user has to press <Previous Calculations> button and select the specific exposures. The cumulative embryo dose from the selected exposures is then calculated and presented.

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		Date 16/10/2015
PATIENT EXPOSURE Radiography	Computed Tomography (CT)	
	8-12 week	
Fluroscopy	Clear	
Computed Tomography	Embryo Depth (cm) g Tube Load (mAs) 550	
OCCUPATIONAL EXPOSURE	Tube Voltage (kV) 110 •	
Fluroscopically-guided Procedures	Plach 130 Beam Collimation (mm) 24 0	
	Patient Circumference 90 (d)	
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		4 . radiography 2015-10-16 09:14:23 [Kidney PA] ED:1.709 mGy		
		5 . radiography 2015-10-16 09:15:03 [Abdomen AP] ED:32.906 mGy		
		6 . radiography 2015-10-16 09:16:19 [Abdomen AP] ED:32.906 mGy		
		7 . radiography 2015-10-16 10:16:42 [Abdomen AP] ED:32.906 m3y		
		8 . fluroscopy 2015-10-16 16:22:01 [] ED:		
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		12. ct 2015-10-16 17:08:49 [] ED:23.621 mGy	V	
		type -ct depth = 8 mas = 350 kup = 110 pitch = 1.38 beam = 24 pp = 90 ctolf = 17.3 ctolf = 8.3 z1 = -10 z2 = 12 ed = 23.621 mGy risk = 0.28%		
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		Delete Saved Calculations		

<u>Return to HELP</u>

Occupational Exposure of Pregnant Employees

<u>Module 4</u>: Occupational exposure from fluoroscopically guided procedures

General information

CODE occupational exposure from fluoroscopically guided (FG) interventional procedures module provides prospective or retrospective estimates of absorbed dose to the embryo of a pregnant employee involved in such procedures.

A C-arm unit and an anthropomorphic phantom simulating an average patient were used to determine scatter exposure rates at specific locations over a 50 cm x 50 cm grid around the table of the angiography suite. Data were collected for all commonly used fluoroscopic projections centered on three different anatomical regions i.e. chest, abdomen or pelvis. These projections are shown in Table 3. For each projection, exposure data were obtained for various combinations of tube voltage and total filtration. Exposures in μ Sv/h were measured at operator's waist i.e. 110 cm from the floor. Projection-specific spatial 2-d maps of normalized to dose-area product (DAP) scatter exposure rate were derived.

Scatter exposure data were obtained for various fluoroscopy beam field sizes. Monte Carlo simulation was employed to determine the exposure reduction factor achieved by using radioprotective apron for different values of operating tube voltage and protective apron lead equivalence.

Scatter exposure at the specific position of the pregnant employee in the operating room is converted to embryo dose using gestation stage-specific air kerma to embryo dose conversion factors previously published (Damilakis et al, JCE 2005).

Embryo dose (ED) from a specific FG procedure for which n different projections are involved is calculated from:

$$ED = \sum_{i}^{n} (NE_{i}(p, kV, filtration) \times DAP_{i} \times f_{field \ size} \times f_{gest.stage} \times f_{Pb \ apron})$$

where NE_i is the normalized scatter exposure at the waist level for the fluoroscopic projection i determined for the same tube voltage and total beam filtration, DAP_i is the cumulative DAP recorded for the specific projection i, $f_{field size}$ is the correction factor for the specific beam field size at entrance skin surface, $f_{gest.stage}$ is the correction factor for the selected gestational stage of the pregnant employee, and $f_{Pb apron}$ is the correction factor for the specific lead apron worn by the pregnant employee.

TABLE 3. The fluoroscopic projections investigated			
Projection*	Abbreviation		
Posterior-Anterior	РА		
Posterior-Anterior/Caudal 30°	PA/CAU30		
Posterior-Anterior/ Cranial 30°	PA/CRA30		
Right Anterior Oblique 30°	RAO30		
Left Anterior Oblique 30°	LAO30		
Left Anterior Oblique 45°	LAO45		
Right Anterior Oblique 45°	RAO45		
Left Lateral	LLAT		
Right Lateral	RLAT		

		CODE Help
Left Anterior Oblique 40°/Caudal 25°	LAO40/CAU25	
Right Anterior Oblique 40°/Caudal 25°	RAO40/CAU25	
Left Anterior Oblique 40°/Cranial 25°	LAO40/CRA25	
Right Anterior Oblique 40°/Cranial 25°	RAO40/CRA25	
Left Anterior Oblique 20°/Caudal 20°	LAO20/CAU20	
Right Anterior Oblique 20°/Caudal 20°	RAO20/CAU20	
Left Anterior Oblique 20°/Cranial 20°	LAO20/CRA20	
Right Anterior Oblique 20°/Cranial 20°	RAO20/CRA20	

* All projection angulations refer to the position of image intensifier with respect to the vertical axis

How to use the occupational exposure module?

	COnceptus Dose Estimation
	Date 16/10/201
PATIENT EXPOSURE Radiography	CODE gives you the oportunity to calculate either dose to the conseptus of a pregnant patient or lose to the conseptus of pregnant personnel. Please make a selection from the menu on the left.
Fluroscopy Computed Tomography OCCUPATIONAL EXPOSURE	
Fluroscopically-guided Procedures	
PRIMAR OLIGIARIANS BAY OLIGIARIANS BAY	
	© Copyright 2014

The user has to select the occupational exposure module.

The user has to define/provide the following data regarding the occupational exposure of the pregnant employee:

1. <u>Anatomical region of interest:</u> A pull down menu guides the user to define the exposed patient anatomical region. Three options are available: chest, pelvis and abdomen.

Statement of Matter and Matter	COnceptus Dose Estimation	vee:2 1.0000/T
PATIENT EXPOSURE		Date 16/10/2015
Radiography	Fluroscopically-guided Procedures Clear	
Fluroscopy	Natonical region of Interest Projection Projection Cick to select: Cick to select: Cick to select: Cick to select: Cick	
	Tube Voltage (kV) Filtration (mm Al + mm Cu)	
OCCUPATIONAL EXPOSURE	Field Size (cm ²)	
Fluroscopically-guided Procedures	Projection DAP (Gycm ²)	
	Gestational Stage Select:	
	Apron lead equivalent protection (mm Pb)	
INTERNET INTERNET		
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2. <u>Orientation of the projection:</u> A pull down menu, guides the user to select one of 17 different fluoroscopic beam projections illustrated in Table 3.

<u>ن</u>	COnceptus Dose Estimation	ved 1.000/7 Date 16/102015
PATIENT EXPOSURE Radiography Duroscopy OCCUPATIONAL EXPOSURE Fluroscopically-guided Procedures Procedures Exposure Statement Procedures Procedure	Fursescopically-guided Proceedures Const Automatical region of interest Protection Tata Manage (W) Ana Manage (
	© Copyright 2014	

3. <u>Exposure parameters of the examination:</u> The user has to define tube potential (kV), and tube inherent/added filtration (mm Al/mm Cu) used for the specific projection selected.

	COnceptus Dose Estimation	uerd LODOUT
	Hame About Code Help	Date 16/10/2015
PATIENT EXPOSURE Radiography	Fluroscopically-guided Procedures Clear	
Fluroscopy Computed Tomography Exposure Parameters	Anatomical region of Interest CHEST Projection PA Tube Voltage (M) 70 8	
OCCUPATIONAL EXPOSUR	Filtration (mm A1 + mm Cu) 5 62 Field Size (cm ²) B X B Projection DAP (Sycm ²) (m) (m) (m)	
Procedures	Projection DAP (Syow) 38 Gestational Stage Select Apren Head equivalent protection (nm Pb) 8	
	© Copyright 2014	

4. <u>Field size</u>: The user has to select the field size of the fluoroscopic beam for the selected projection (acceptable values 25 cm^2 to 625 cm^2).

	COnceptus Dose Estimat	ion	unez 1.000UT
	Home About Code Help		
PATIENT EXPOSURE Radiography	Fluroscopically-guided Procedures Cle	ar	Date 16/10/2015
Euroscopy Computed Tomography OCCUPATIONAL EXPOSURE Furoscopically-guided Procedures	Anatomical region of Interest Projection Table Voltage (XV) Filtration Inter AL - non Cu) Field Stare (cm) Projection SUP (Upcm) Gestational Stage Agron lead equivalent protection (non Pb)	OREST PA 70 8 ♦ 92 81 93 ¥ 10 Select.	
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5. <u>DAP</u>: The user should define the DAP value of the specific selected projection in Gy cm^2 .

	COnceptus Dose Estimation	
		Date 16/10/2015
PATIENT EXPOSURE		
Radiography	Fluroscopically-guided Procedures Clear	
Fluroscopy	Anatomical region of interest CHEST	
	Projection PA •	
Computed Tomography	Tube Voltage (kV) 70	
OCCUPATIONAL EXPOSURE	Filtration (mm Al + mm Cu) 5 • 0.2	
	Field Size (cm²) 12 🔅 🗙 12 🔅	
Fluroscopically-guided Procedures	Projection DAP (Gycm ²)	
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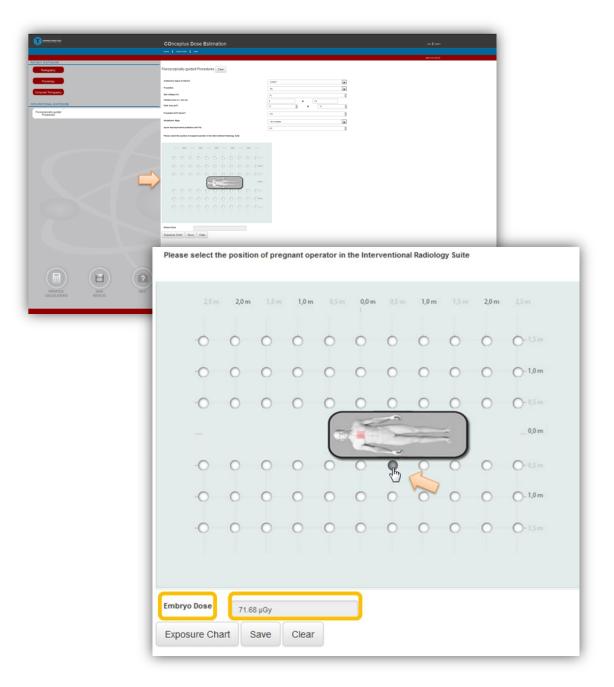
6. <u>Gestational stage</u>: A pull down menu guides the user to select the gestational stage of the exposed pregnant employee i.e. 1st, 2nd or 3rd trimester.

	COnceptus Dose Estimation	
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Fluroscopy Computed Tomography	Anatomical region of interest CriEST ■ Projection FA ■ Table Voltage (M) F0 ● Fill station (mm Al + mm Cu) 5 ≠ 0 Field Station(************************************	
Fluroscopically guided Procedures	Field Size (on?) Projection DMP (System) Generational Stage Apron lead equivalent protection (num Pb) Select • • Select • •	
PRODUCTION AND AND AND AND AND AND AND AND AND AN		
	© Copyright 2014	

7. <u>Lead apron:</u> When the pregnant employee uses a radioprotective lead apron, the user has to define Pb-equivalent thickness of the apron in mm (acceptable values 0.0 to 0.5 mm Pb)

	COnceptus Dose Estimation	
MENTEROPORT	Processed of the processes of the second sec	
	Apron lead equivalent protection (mm Pb)	0.5
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8. <u>Position of pregnant operator:</u> The user has to define the position of the pregnant operator in the operating room by selecting the corresponding bullet on the operating room grid show.



When all the necessary data has been supplied, the dose absorbed by the embryo of the pregnant employee is calculated and presented in the corresponding field. The scatter exposure map corresponding to the selected fluoroscopic projection is presented if the user presses the button <Exposure chart>.

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Using the <Save Results> button, the registered user can also save a calculation, including all exposure data and date and time of submission for later revision.

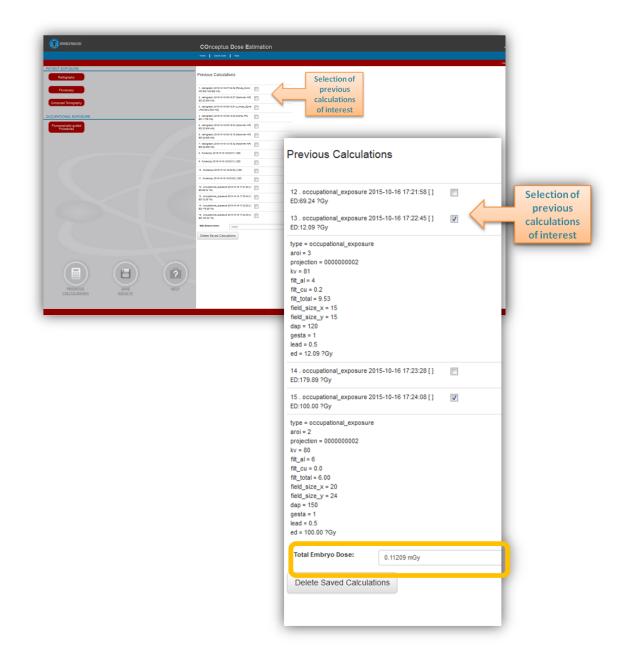
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Additionaly, the user has the oppurtunity to calculate the cumulative embryo dose.from several fluoroscopic exposures for which calculation of embryo dose has been performed and saved. The user has to press <Previous Calculations> button and select the specific exposures. The cumulative embryo dose from the selected exposures is then calculated and presented.

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	COnceptus Dose Estimation		
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