Foetal dose and risk calculations for Trauma CT scans performed at LGI MTC

Within the Leeds Trauma Centre, a range of CT scan protocols are used based on the presenting condition of the patient. Details of these trauma scan protocols are summarised in Table 1.

Protocol name	Clinical Indications	Scans
T H&N	Traumatic injury to head and neck only	Head and C-spine
T Bleed Full	Haemodynamically unstable trauma with prior clinical suspicion of bleeding/vascular injury	Head, C-spine, Chest-abdomen-pelvis, delayed abdomen-pelvis
T Bastion	Stable trauma patients	Head, C-spine, Chest-abdomen-pelvis
T CAP	Stable trauma patients (no head/neck injuries)	Chest-abdomen-pelvis
H T	Trauma (cover orbits if trauma to the eyes)	Brain only

Table 1 LTH CT trauma scanning protocols

In order to evaluate typical foetal exposures resulting from examinations using the scan protocols in Table 1, a series of calculations were performed using the NCICT v3 software[1]. This software allows calculations to be performed for up to 8 gestational ages, from 8 - 38 weeks gestation. In addition, the dose to the uterus of a non-pregnant female was also calculated as an indication of the likely foetal dose for less than 8 weeks gestation. It should be noted that these calculations are based on an average size female patient, and are therefore a broad indication of the typical foetal doses that may be received for an individual patient.

Typical radiation doses to adult trauma patients have been established from a routine patient dose audit performed in early 2020 and were used as the basis on the foetal dose calculations. Due to the increase in size of the mother's chest, abdomen and pelvis over the course of pregnancy the scanner will automatically adjust the scan parameters, thereby increasing the dose, to account for the increased size and attenuation. In order to reflect this we have allowed for a 5% increase in the dose levels for scans of the chest, abdomen and pelvis for each of the gestational ages.

For each of the anatomical scan regions, the calculated foetal doses, across the 8 gestational ages are shown in Table 2.

	Foetal gestation (weeks)								
Scan	0	8	10	15	20	25	30	35	38
Head	0	0	0	0	0	0	0.01	0.01	0.01
C-spine	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03
CAP	7.93	10.47	11.43	11.51	12.24	11.61	11.45	12.1	12.44
AP	7.81	10.31	11.26	11.33	12.05	11.41	11.26	11.89	12.21

Table 2 Foetal dose in milli Gray (mGy) for each gestational age

This table clearly shows that foetal doses resulting from scans above the diaphragm are minimal, typically much less than 1mGy. The absolute foetal doses received will to some degree depend on the exact size and position of the foetus and the mother's size, which cannot be accounted for within the available software.

Based on the scan protocols listed in Table 1, and the foetal doses for each scan region presented in Table 2, the typical total foetal dose for each scan protocol is shown in Table 3.

	Foetal gestation (weeks)								
Protocol	0	8	10	15	20	25	30	35	38
T H&N	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.04
T Bleed Full	15.75	20.79	22.7	22.85	24.3	23.03	22.73	24.02	24.69
T Bastion	7.94	10.48	11.44	11.52	11.87	11.62	11.47	12.13	12.48
T CAP	7.93	10.47	11.43	11.51	11.86	11.61	11.45	12.1	12.44
H T	0	0	0	0	0	0	0.01	0.01	0.01

Table 3 Total foetal doses in mGy for each scan protocol

The 2009 report of the Health Protection Agency[2], presents the associated risk of childhood cancer as 1 in 10,000 per mGy foetal dose (0.01% per mGy) and the natural, underlying risk of childhood fatal cancer as 1 in 500 (0.2%).

The additional risks of fatal childhood cancer arising from the foetal doses in Table 3 are shown in Table 4

	Foetal gestation (weeks)								
Protocol	0	8	10	15	20	25	30	35	38
T H&N	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0003	0.0004
T Bleed Full	0.1575	0.2079	0.2270	0.2285	0.2430	0.2303	0.2273	0.2402	0.2469
T Bastion	0.0794	0.1048	0.1144	0.1152	0.1225	0.1162	0.1147	0.1213	0.1248
T CAP	0.0793	0.1047	0.1143	0.1151	0.1224	0.1161	0.1145	0.1210	0.1244
H T	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001

Table 4 Additional risks of childhood cancer arising from the scan protocols (%)

Additional risks of less than 0.5% are considered to be low, whilst additional risks of less than 0.01% are considered to be very low[2].
The only scans resulting in any notable increase in the fatal cancer risk are those involving the chest, abdomen and pelvis of the patient. The highest doses, and therefore the highest risks, arise from the T Bleed Full scan protocol for haemodynamically unstable patients, as this scan protocol includes two scans of the abdomen and pelvis. The additional risk associated with this scan protocol results in a doubling of the natural underlying risk of 0.2%. Although there is a doubling of the childhood cancer risk, the absolute increase in the lifetime cancer risk is likely to be less than 1%[2].

This document serves as a summary of the doses and risks associated with the CT scanning protocols and is intended as a reference document for the Emergency Department Clinicians.

In addition, we have presented some suggested patient information wording which could be used to communicate the risks to patients in advance of the scan. The wording should be reviewed by the Clinicians and subsequently a final version agreed by the Clinicians and Medical Physics.

It is recommended that the content of this document should be reviewed in two years and/or following any changes to the clinical CT scanning protocols which may affect the typical foetal doses and risks.

References

1: NCICT: a computational solution to estimate organ doses for pediatric and adult patients undergoing CT scans, Choonsik Lee et al 2015 J. Radiol. Prot. 35 891

2: Protection of pregnant patient during diagnostic medical exposures to ionising radiation. Advice from the Health Protection Agency, The Royal College of Radiologists and The College of Radiographers, 2009

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