Traumatic Extra-Axial Hemorrhage: Correlation of Postmortem MSCT, MRI, and Forensic-Pathological Findings

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Introduction: In clinical medicine, neuroimaging techniques play an important role in the diagnostics of traumatic brain injury (TBI). It may be less obvious, however, that the accurate detection and localization of intracranial hemorrhages is also of paramount importance in forensic medicine for the differentiation and documentation of fights and accidents in dead as well as in living injured persons. With the increasing application of radiological imaging methods in forensic medicine [1, 2], a direct comparison of CT or MRI data with autopsy findings not only offers an opportunity for a quality control of radiological methods, but it also helps to evaluate the applicability of these imaging techniques for the abovementioned forensic investigations. The aim of this study was to evaluate retrospectively the diagnostic accuracy of in situ postmortem CT and MRI in the detection of primary traumatic extra-axial hemorrhage in view of a prospective application to forensic routine casework.

Methods: 30 forensic neurotrauma cases and 10 non-traumatic controls underwent both in situ postmortem cranial MSCT and MR imaging before autopsy. First, the MR images were obtained on a 1.5T whole body scanner (GE Signa) using a conventional quadrature head coil. Transverse T1-weighted spin echo (TR=400-600ms, TE=13-14ms) and T2-weighted fast spin echo (TR=3.6-5s, TE=90-105ms) sequences were performed. Additionally, in 25 cases gradient-recalled echo sequences were acquired. Unenhanced CT of the head was performed subsequently with either a four- or eight-detector row helical scanner (Lightspeed, GE). The mean interval between death and imaging was 37h for MRI and 38h for CT, respectively. Radiological data was independently read by two board-certified neuroradiologists, who were blinded to all subject information. Extra-axial hemorrhagic findings were evaluated in 89 pre-defined anatomical localizations (14 epidural, 25 subdural and 50 subarachnoid locations), i.e., in the 40 bodies a total of 3560 locations were examined. Since findings in 131 locations were excluded for technical reasons, 3429 locations remained for statistical analysis. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of both imaging modalities concerning the detection of extra-axial hemorrhage were calculated based on forensic autopsy protocols and photographic documentation serving as a gold standard. Statistical significance was calculated using the McNemar test. Pairwise kappa values (κ) were calculated for interobserver agreement separately for hemorrhage types and modalities.

Results: Forensic-neuropathologic examination revealed extra-axial hemorrhagic lesions at 1142 sites (29 epidural, 331 subdural, 782 subarachnoid) of the evaluated 3429 locations. The results of the analysis of the detection of hemorrhagic localizations (Table) generally show an equally good accuracy, sensitivity, and specificity for both CT and MR imaging. Relating to the different extra-axial hemorrhagic types, MRI was more sensitive than CT in the detection of subarachnoid hemorrhagic sites (p= .001), whereas no significant difference resulted from the detection of epidural and subdural hemorrhagic localizations (p= .248 and p= .104, respectively). The specificity of MR imaging for the detection of non-hemorrhagic epidural, subdural and subarachnoid localizations was significantly better than that of CT (p= .023, p< .001 and p= .002, respectively). Improvements could be made particularly for epidural sites. Interobserver agreement (kappa values) was substantial for both CT and MRI.

Results of Postmortem CT and MRI for the Detection of Extra-Axial Hemorrhagic Sites for the two Readers (pooled) including Interobserver Agreement (Kappa Values)

Imaging Technique	Extra-Axial Hemorrhage Type	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	Kappa Value κ
CT							
	Total	82	92	84	91	89	.76
	Epidural	26	99	58	96	95	.61
	Subdural	79	88	77	89	85	.63
	Subarachnoid	85	92	87	90	89	.80
MRI							
	Total	83	94	87	92	90	.77
	Epidural	22	100	72	96	95	.55
	Subdural	77	90	81	88	86	.66
	Subarachnoid	87	93	90	91	91	.80

Discussion: For the detection of primary traumatic extra-axial hemorrhagic sites, postmortem CT generally performs equally well as postmortem MRI. The overall diagnostic sensitivity is similar with no significant difference between both modalities. However, the specificity of postmortem MRI is significantly better than that of postmortem CT, which is due to the ability of MRI to better visualize non-hemorrhagic areas in artefact-dependent localizations. Additionally, positive MR findings are more predictive of extra-axial hemorrhagic sites compared to CT due to a smaller number of false-positive findings. Although the interobserver agreement for CT and MRI is substantial, there is still room for improvements, particularly concerning the detection of thin blood layers. Although clinically not important, these very discrete findings are of great importance in forensic medicine and can be decisive for legal investigations.

Conclusions: CT and MRI are of comparable potential as diagnostic tools for traumatic extra-axial hemorrhage in dead as well as in living injured persons in forensic medicine.

References: [1] Patriquin L et al. J Magn Reson Imaging 2001;**13**:277-287; [2] Thali MJ et al**.** J Forensic Sci 2003;**48**:386-403