H17 Age Determination of Traumatic Subcutaneous Hematomas Using 3.0T Magnetic Resonance Imaging (MRI): A Feasible Approach

Kathrin Ogris, MD, Medical University of Graz, Institute of Forensic Medicine, Universitaetsplatz 4/II, Graz, Styria 8010, AUSTRIA; Thomas Widek, MSc, Ludwig Boltzmann Institute, Clinical Forensic Imaging, Universitaetsplatz 4/2, Graz, Styria 8010, AUSTRIA; Martin Söllradl, MSc, Medical University of Graz, Department of Neurology, Auenbruggerplatz 22, Graz, Styria 8036, AUSTRIA; Patrick P. Torreiter, MD, Medical University of Graz, Institute of Forensic Medicine, Universitaetsplatz 4/II, Graz, Styria 8010, AUSTRIA; Peter Grabuschnigg, MD, Medical University of Graz, Institute of Forensic Medicine, Universitaetsplatz 4/II, Graz, Styria 8010, AUSTRIA; Thorsten Schwark, PhD, Medical University of Graz, Institute of Forensic Medicine, Universitaetsplatz 4/II, Graz, Styria 8010, AUSTRIA; and Eva Scheurer, MD, Institut für Rechtsmedizin, Pestalozzistr.22, Basel 4056, SWITZERLAND*

After attending this presentation, attendees will recognize that the dating of soft tissue hematomas is particularly important for the reconstruction of criminal acts, such as child abuse cases, and thus may have significant medicolegal consequences. Accurate timing of injuries can define or at least set limits on a period of time during which a crime took place and can lead to an inclusion or exclusion of potential suspects.

This presentation will impact the forensic science community by underlining the importance of radiological methods in forensic medicine.

In clinical forensic medicine, it is often important to determine the time of origin of soft tissue injuries. As subcutaneous hematomas are usually not relevant for clinicians, only limited knowledge exists regarding the detection and dating of traumatic lesions in the subcutaneous fatty tissue using Magnetic Resonance Imaging (MRI); however, visual assessment of external hematoma color, the currently used method for estimating hematoma age, is unreliable due to inter-individual differences and its great inter-observer variability.[1] Consequently, dating of hematomas is difficult, due to the lack of an objective and reliable method. The first MRI studies revealed that the contrast behavior between blood and soft tissue could be used to obtain objective information on blood characteristics and temporal changes.[2] Based on initial results regarding artificially created hematomas, the goal of this study was to create an age estimation model and to validate this approach with real hematomas of known age.

In 30 healthy volunteers, without coagulation disorders or medication influencing blood clotting, artificial hematomas were created by injecting 4ml of autologous blood into the subcutaneous fatty tissue of the thigh after a basis MR scan. The artificial hematomas were scanned repetitively at different points in time (directly after the injection and 3h, 24h, 3d, 7d, and 14d after the injection). All measurements (n=180) were performed on a 3T scanner using a multifunctional coil. The MR sequence protocol consisted of a Proton Density-weighted Turbo Spin Echo (PDwTSE) sequence with fat saturation (Spectral Adiabatic Inversion Recovery (SPAIR)) in oblique and axial orientation. Data were analyzed by measuring signal intensities in the hematoma and fatty tissue. Afterward, contrast coefficients were calculated and averaged at single points in time and approximated by a mono-exponential fit.[3] Based on the fitting curve, three contrast cut-off values ($\geq$0.75, <0.75 – $\geq$0.60 and <0.60) for three age categories ($\leq$24h, >24h – $\leq$7d and >7d) were defined, and the suitability of these thresholds was validated with real traumatic hematomas. Therefore, in ten healthy volunteers (exclusion criteria as stated above), hematomas were created using blunt force (paintball shot to the thigh) following a basis MR scan. For all consecutive MR measurements (n=60), the same setup as for the artificial hematomas was used. Subsequently, blinded data evaluation and age categorization according to the predefined thresholds were performed.

Overall, nearly 70% of all investigated hematomas were categorized correctly. For the first age category (hematoma age $\leq$24h), a sensitivity of 73% and a specificity of 93% were found. The Positive Predictive Value (PPV) was 92% and the Negative Predictive Value (NPV) was 78%. In the second age category (hematoma age <24h – $\leq$7d), the sensitivity was 70%, the specificity 68%; PPV was 52%, and NPV was 82%. For the third age category (>7d), a sensitivity of 50%, a specificity of 92%, a PPV of 56%, and a NPV of 90% were calculated.

All real hematomas were detectable at each point of time using MRI. The majority of the tested hematomas was correctly classified, but most notable was the quite accurate age estimation of hematomas within 24h of origin. In forensically relevant cases of living victims, the detection of recent bruises is especially important because it is a well-known fact that not every hematoma is immediately visible. The results of this feasibility study reveal that the presented approach for hematoma dating is a suitable, objective, and examiner-independent method to detect and estimate the age of bruises. The implementation of an objective MR-based age estimation approach may consequently improve the forensic expert's report in court, and thus ensure a higher degree of legal certainty. The applicability of the proposed model will be further validated with a higher number of hematomas of different ages and additional MR sequences.

Reference(s):

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*Presenting Author