Applying Deep Learning to Establish a Total Hip Arthroplasty Radiography Registry: A Stepwise Approach

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INTRODUCTION: Establishing imaging registries for large patient cohorts is challenging as manual labeling is tedious and relying solely on DICOM (digital imaging and communications in medicine) metadata is prone to errors. We endeavored to establish an automated hip and pelvis radiography registry of total hip arthroplasty (THA) patients by utilizing deep learning pipelines. The aims of the study were to use these automated pipelines to identify all pelvis and hip radiographs with appropriate annotation of laterality and presence or absence of implants, and secondly to automatically measure acetabular component inclination and version for THA images.

METHODS: We retrospectively retrieved 846,987 hip and pelvis radiography DICOM files from 20,378 patients who had primary or revision THA performed at our institution from 2000-2020. Metadata for DICOMs were screened followed by extraction of imaging data. Two deep learning algorithms (an EfficientNetB3 classifier and a YOLOv5 object detector) were developed to automatically determine the radiographic appearance of all DICOMs. Additional deep learning algorithms were used to automatically measure the acetabular angles on anteroposterior (AP) pelvis and lateral hip radiographs. Algorithm performance was compared to human annotators on a random test sample of 5,000 radiographs.

RESULTS: Deep learning algorithms enabled appropriate exclusion of 209,331 DICOMs (24.7%) as misclassified non-hip/pelvis radiographs or from corrupted pixel data. The final registry was automatically curated and annotated in <8 hours and included 168,551 AP pelvis, 176,890 AP hip, 174,637 lateral hip, and 117,578 oblique hip radiographs. The algorithms achieved 99.9% accuracy, 99.6% precision, 99.5% recall, and 99.6% F1-score in determining the radiograph appearance.

DISCUSSION AND CONCLUSION: We developed a highly accurate series of deep learning algorithms to rapidly curate and annotate THA patient radiographs. This efficient pipeline can be used by other institutions or registries to construct radiography databases for patient care, longitudinal surveillance, and large-scale research. The stepwise approach for establishing a radiography registry can further be used as a workflow guide for other anatomic areas.