Purpose:
Historically, the development of computational phantoms for radiation dosimetry have primarily been directed at capturing and representing adult and pediatric anatomy, with less emphasis devoted to models of the human fetus. As concern grows over possible radiation-induced cancers from medical and non-medical exposures of the pregnant female, the need to better quantify fetal radiation doses, particularly at the organ-level, also increases. To address this need a series of hybrid computational phantoms was constructed for fetal ages 8, 10, 15, 20, 25, 30, 35 and 38 weeks post-conception.

Methods:
Two specimen-specific fetal hybrid computational phantoms were constructed using high-quality magnetic resonance imaging (MRI) and computed tomography (CT) image sets obtained for two well-preserved fetal specimens aged 11.5 and 21 weeks post-conception. Individual soft tissue organs, bone sites, and outer body contours were segmented from the images using 3D-DOCTORTM and imported into the 3D modeling software package RhinocerosTM for further modeling and conversion of soft tissue organs, certain bone sites and outer body contours to deformable non-uniform rational B-spline (NURBS) surfaces. The two specimen-specific phantoms, along with a modified version of the 38 week UF hybrid newborn phantom, comprised a set of base phantoms from which a series of hybrid computational phantoms was derived for fetal ages 8, 10, 15, 20, 25, 30, 35 and 38 weeks post-conception.

Results:
A set of fetal computational phantoms accounting for the following age-dependent parameters: (1) variations in skeletal size and proportion, (2) bone-dependent variations in relative levels of bone growth, (3) variations in individual organ masses and total fetal masses and (4) statistical percentile variations in skeletal size, individual organ masses, and total fetal masses.

Conclusions:
The resulting series of fetal hybrid computational phantoms is capable of organ-level and bone-level internal and external radiation dosimetry for human fetuses of various ages and weight percentiles.