The first series of Iranian BREP phantoms

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***Abstract*— A new family of boundary representation (BREP) reference phantoms, based on the Iranian reference masses for adults of both genders and also three non-reference Iranian pediatric phantoms were developed. We further extended this phantom series to include pregnant women with fetuses of various ages and weight percentiles for radiation protection purposes.**

Index Terms—BREP phantoms; reference phantoms; pediatric phantoms; other ethnic groups

I. INTRODUCTION

Looking at the soaring mountains of computational phantoms' applications from where we stand on the hillside, the highest visible mountaintop is the scientific contribution of personalized phantoms in medicine. As an Iranian research group, we are standing on the first station through the climbing route which is the development of Iranian BREP phantoms. Toward this goal, we could get a detailed understanding of human anatomy, and an invaluable experience in reading medical images such as CT and MR, and in 3D graphical modeling with polygon mesh surfaces and NURBS. Also, we explored systematic anatomical differences between Iranians and other ethnic/racial groups. Further, we gathered a large library of HU values, shapes and locations for various organs and tissues. In addition, our perception of which components of secondary radiation could be important was influenced by performing dosimetric calculations for these phantoms in different exposure scenarios. Here, we have a better understanding of our next stations toward the mountaintop which we think are (1) auto-segmentation, (2) real-time specific-posture modeling, (3) fast Monte Carlo simulation, and (4) radiobiological modeling. Through this way, the inscriptions left by previous investigators were our guides [1-3], and we would be so proud to share our experiences with this workshop.

II. METHODS

A. Anthropometric characteristics of Iranian individuals

Total weight, height and extremities and trunk weight, were obtained from a commercially available body analyzer. The collected data showed a normal distribution of weight and height which confirmed appropriate homogenous sampling of individuals.

B. Specifications of internal organs

The CT images of chest-abdomen-pelvis and head-neck of 100 patients were provided and the contours of their distinguishable organs were determined [4]. The organ volumes were then evaluated and utilized for determination of reference organs' mass of Iranian individuals.

C. Conversion of patient-specific models to reference phantoms

Two adult male and female volunteers were recruited which had heights and weights close to Iranian average values. The total body of volunteers were partially imaged using a 1.5T Siemens MagneTom vision. The patient-specific models were then converted to reference models using 3D tools in Rhinoceros software.

D. Pregnant females

The adult female reference phantom was then converted to pregnant models at gestational ages using the method discussed in [5-8].

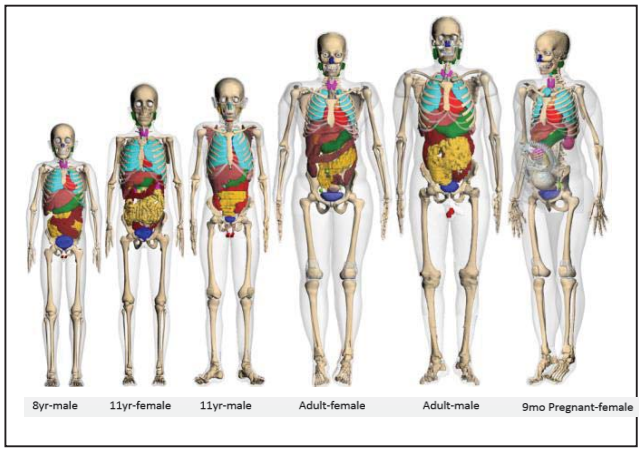

Figure 1. 3D front view of Iranian computational phantoms.

III. RESULTS

A family of BREP reference phantoms are presented including two adult male and female reference phantoms, a subgroup of pregnant reference phantoms at 3, 6 and 9 months of gestation, and three non-reference pediatric phantoms. The

organs' mass values of the reference models are conformed to the reference data of Iranian population.

The pregnant subgroup involves fetuses at 10th, 50th, and 90th growth percentiles. Moreover, the fetal models include age-specific skeletal structures pertained to the ossification of fetal skeleton. The non-reference pediatric models also include two 11 years old male and female models, in addition to an 8 years old male phantom.

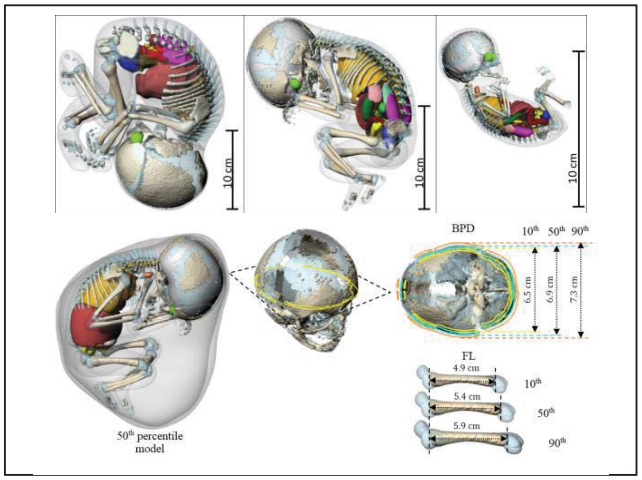

Figure 2. 3D models of the reference fetus at 1st, 2nd, and 3rd trimester of pregnancy (Top). A illustration of diffrences between 10th, 50th, and 90th percentiles for 6 month fetus (Bottom).

IV. Conclusion

This phantom series is being constructed based on Iranian reference data. This advantage makes them appropriate to use for producing dose estimates for specific radiation protection purposes in our country. We intend to update photon and electron SAFs for internal emitters as well as organ dose conversion coefficients using our phantoms following the recent ICRP Recommendations.

Another advantage of this series is to be BREP phantoms, the latest generation of phantoms ever created worldwide. However, the children models are non-reference models which may be known as one of the drawbacks of this phantom series. The children models remained patient-specific because the lack of the data from Iranian pediatrics.

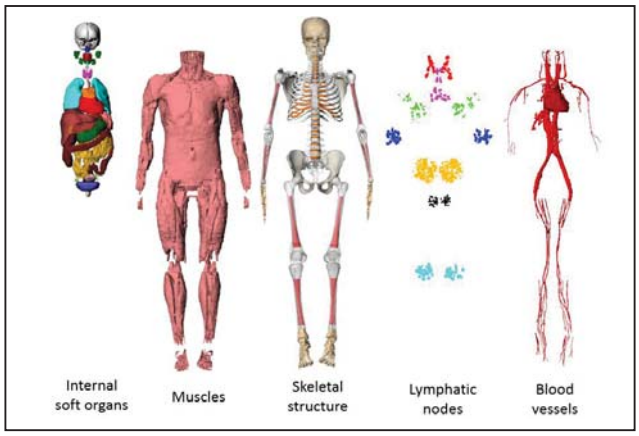

Figure 3. Detailed structure of Iranian adult female reference phantom.

In future, we will improve this series to high quality BREP phantoms by adding details of thin target layers to respiratory and alimentary tract models according to the latest ICRP publications.

Albeit, our secondary objective in developing phantoms for people lives in our country was exploring the way of phantom construction manually, in order to make an automatic process in near future to obtain patient specific models.

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