CQ19 What are useful findings for sex determination/estimation in postmortem images?

Grade of recommendation: C1

Sex (gender) is determined by the morphological characteristics of the external and internal genitalia, even when performed on postmortem images as well as in macroscopic examinations. Genitalia may be recognizable on CT even in severely putrefied or destroyed conditions of corpses, especially the penis and prostate in males and the vagina and uterus in females. When it is difficult to identify the genitalia, the sex is estimated from bone morphological characteristics and anthropological measurements. The pelvis offers the simplest distinguishing characteristic to estimate the sex. However, when secondary sexual characteristics are not fully developed, it may be difficult to estimate the sex using morphological differences.

Explanation---

Sex determination based on morphological characteristics of external and internal genitalia in postmortem images

There is a report in which postmortem CT screening was incorporated as one of the disaster victim identification (DVI) processes for bushfire victims. In 98 (61%) of the 161 cases that were recognizable as human on CT, external or internal genital or personal items, such as brassiere underwire, jewelry, and watches, that were helpful for an estimation of the sex were identified. Despite the bodies being severely burned, external or internal genitals were identified clearly or in a partially destroyed state in 81 cases (50%). The penis and prostate in men, and the breasts, vagina, labia, and uterus in women, were recognizable. However, two of the 43 bodies estimated to be females from the CT were male. One was where only bone remained with jewelry, and the other was thought to have a severely disrupted uterus, which was however retrospectively determined to most likely be the rectum [1].

Sex estimation from bones on postmortem images

1) Sex estimation from morphological characteristics

On CT it is straightforward to simply visualize the skeletal morphology regardless of the condition of a corpse, and the bones may be rotated noninvasively and cut at any desired slicing [2]. However, few studies of sex estimation from bone morphological characteristics using CT have been reported. Like dry bone studies, the morphology of the pelvic bone such as the subpubic angle, the angle and shape of the greater sciatic notch, and the shape of the pelvic cavity, as well as the morphology of the skull such as the glabella and superciliary arch, forehead, orbit, supraorbital ridges, the mastoid process, muscle ridges in the occipital region, and mandible, can be useful. In a study of sex and age estimation from the skull and pelvis of a CT-generated “virtual skeleton”, three anthropologists correctly determined the sex in all cases [3]. However, the accuracy of a sex estimation of skeletal remains varies with the age of the subject, the degree of fragmentation of the bones, and biological variability. An anthropological study of dry bones reported 100% accuracy using the whole skeleton, 95% using the pelvis, 92% using the skull, and 98% using the pelvis plus skull, but with marked bias of the sex ratio in the collection [4]. A study of African-American skeletons recorded 94% accuracy using the whole skeleton and 77% using the skull and mandible [5]. Sex estimation based on bone morphological characteristics on CT may result in a similar accuracy as that of dry bone studies, but further studies are needed to establish this.

2) Sex estimation from anthropological measurements

Anthropological measurements of sex differences are used for sex estimation when bones are fragmented, the subject may be a child or young adult, and when objective data are needed in addition to the morphological characteristics described above. The estimation is performed by substituting the measurements into a formula from discriminant analysis in many morphometry studies. The accuracy of sex estimations varies according to the formula used, because the measurement points with sex differences, discriminant formulae, and discriminant scores may vary between ethnic groups [6]. Therefore, it is necessary to select a formula based on the bone region, estimated age, and estimated ethnic group.

Many formulae for each measurement point, such as the pelvis [7-9], femur [10], sternum [11], scapula [12], and mandible [13], have been reported in CT studies of the Japanese population. For example, the accuracy of the formulae was 98.1% using the subpubic angle and 89.4% using one side of the angle of the greater sciatic notch and the height between the anterior superior iliac spine and anteroinferior margin of the ischial tuberosity [7]. A discriminant formula for the skull using CT was not located in the present search, but a 91.4% accuracy for a formula using lateral cephalometric radiography [14] and 89.7% accuracy for a formula using dry skulls [15] were reported.

Column---

The pelvis and the skull, which show the most differences between the genders, are commonly used to estimate the sex from bone morphological characteristics. The sternum, the scapula, and the long bones of the extremities, other than the pelvis and the skull, can also be used to estimate the sex from anthropological measurements [6, 16].

Further, sex is generally established by DNA analysis of tissue via amplification for the amelogenin gene [6].

Infrequently, the sex according to the external genitalia, internal genitalia, genes, and family registry are inconsistent due to chromosomal abnormalities, disorders of sexual differentiation, or surgery resulting from the cultural background or a gender identity disorder of the object of the examination [6].

Literature search formula and literature selection (2019/2/3)

PubMed

#	Search formula	Number of documents
1	((postmortem) OR post-mortem) OR "post mortem"	135,908
2	(#1 AND imaging) OR (#1 AND CT) OR (#1 AND "computed tomography") OR (#1 AND MR) OR (#1 AND "magnetic resonance") OR (#1 AND MDCT) OR (#1 AND MSCT) OR (#1 AND X-ray) OR (#1 AND "X ray") OR (#1 AND Xray) OR (#1 AND roentgeno) OR (#1 AND radiograph) OR (#1 AND radiography)	26,626
3	((sex) AND gender) AND (((identification) OR estimation) OR dimorphism)	37,047
4	#2 AND #3	133
5	(victim) AND #3	207
6	(((((((((((imaging) OR CT) OR "computed tomography") OR MR) OR "magnetic resonance") OR MDCT) OR MSCT) OR X-ray) OR "X ray") OR Xray) OR roentgeno) OR radiograph) OR radiography	2,925,641
7	#5 AND #6	23

Ichushi（Medical Journal）(2019/1/21)

#	Search formula	Number of documents
1	((死後/AL) and ((FT=Y) and AB=Y and PT= 会議録除く)) or ((死亡時/AL) and ((FT=Y) and AB=Y and PT= 会議録除く))	4,193
2	(((画像診断/TH or 画像診断/AL)) and ((FT=Y) and AB=Y and PT= 会議録除く)) or (((X 線CT/TH or CT/AL)) and ((FT=Y) and AB=Y and PT= 会議録除く)) or (((MRI/TH or MRI/AL)) and ((FT=Y) and AB=Y and PT= 会議録除く)) or (((X 線/TH or x 線/AL)) and ((FT=Y) and AB=Y and PT= 会議録除く))	406,364
3	((性因子/TH or 性別/AL)) and ((FT=Y) AB=Y PT= 会議録除く)	19,855
4	#1 and #2 and #3	35

From other than search formula

[1, 3-6, 9, 14-16]

References

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[7] Torimitsu S et al: Morphometric analysis of sex differences in contemporary Japanese pelves using multidetector computed tomography. Forensic Sci Int 2015; 257: 530.e1-530.e7 (Level 4b)

[8] Biwasaka H et al: Analyses of sexual dimorphism of reconstructed pelvic computed tomography images of contemporary Japanese using curvature of the greater sciatic notch, pubic arch and greater pelvis. Forensic Sci Int 2012; 219: 288.e1-288.e8 (Level 4b)

[9] Hayashizaki Y et al: Sex determination of the pelvis using Fourier analysis of postmortem CT images. Forensic Sci Int 2015; 246: 122.e1-9 (Level 4b)

[10] Chiba F et al: Sex estimation based on femoral measurements using multidetector computed tomography in cadavers in modern Japan. Forensic Sci Int 2018; 292: 262.e1-262.e6 (Level 4b)

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[14] Nakahara E: Medico-legal application of enumeration by cranial form using Fourier analysis: sex determination application. Nihon Univ Dent J 1994; 68: 343-353 (Level 5)

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