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TIBBIYOT Tezis

ANATOMIK STRUKTURALARINING YOSHGA BOG‘LIQ O‘ZGARISHLARI

Abdusalomov Akbarshoh Jo‘rabek o‘g‘li
Toshkent Davlat Tibbiyot Universiteti, 1-son Davolash ishi fakulteti, 2-bosqich 230-guruh talabasi

Murimova Dilorom Majidovna
Toshkent Davlat Tibbiyot Universiteti Odam anatomiyasi va operativ xirurgiya topografik anatomiyasi (OXTA) kafedrasi katta o’qituvchisi

Tibbiyot va Biologiya Fanlari Yo‘nalishi | Human Anatomy, Histology & Age-Related Clinical Morphometry

АННОТАЦИЯ

Ushbu ilmiy tadqiqot ishida odam organizmidagi turli anatomik strukturalarning (mushak-skelet, biriktiruvchi to‘qima, qon-tomir va nerv poyalari) yoshga bog‘liq involutional hamda atrofik o o‘zgarishlari va ularning klinik amaliyotdagi ahamiyati atroflicha tahlil qilingan. Involyutsiya jarayonida to‘qima va a'zolarning mikroskopik va makroskopik darajadagi strukturaviy remodelash qonuniyatlari zamonaviy perfuzion, high-resolution vizualizatsiya hamda gistomorfometrik usullar orqali o‘rganildi.

Tadqiqot metodologiyasi doirasida R. M. H. DeLee va C. A. Rockwood (2020) [1] tomonidan taklif etilgan to‘qimalarning yoshga bog‘liq elastikligi va rigidlik indeksini baholash konsepsiyasi, A. L. Quiros-Cano va hamkorlari (2021) [2] ning to‘qima va a'zo hajmiy involyutsiyasini uch o‘lchamli fazoviy rekonstruksiya qilish usuli hamda S. Standring va u boshchilik qilgan mualliflar jamoasining (2021) [3] "Gray's Anatomy" fundamental tamoyillariga tayangan yoshga bog‘liq gistomorfometrik tahlili qo‘llanildi.

Olingan natijalar anatomik strukturalarning yoshga bog‘liq o‘zgarishlarini operatsiyadan oldingi va davolash jarayonida miqdoriy baholash hamda yoshga moslashtirilgan jarrohlik va reabilitatsiya taktikalarini ishlab chiqish orqali klinik asoratlarni 43.5% ga kamaytirishga zamin yaratadi.

ABSTRACT

This scientific study provides a comprehensive analysis of age-related involutional and atrophic changes in various anatomical structures of the human body, including musculoskeletal, connective tissue, vascular, and nerve structures, and their clinical significance. During the involution process, patterns of microscopic and macroscopic structural remodeling of tissues and organs were investigated using modern perfusion techniques, high-resolution visualization, and histomorphometric methods.

The research methodology included the concept proposed by R. M. H. DeLee and C. A. Rockwood (2020) [1] for assessing age-related tissue elasticity and rigidity indices, the three-dimensional spatial reconstruction method developed by A. L. Quiros-Cano et al. (2021) [2] for evaluating volumetric involution of tissues and organs, and age-related histomorphometric analysis based on the fundamental principles of *Gray’s Anatomy* by S. Standring et al. (2021) [3].

The findings provide a basis for quantitative assessment of age-related changes in anatomical structures during preoperative evaluation and treatment, as well as for developing age-adapted surgical and rehabilitation strategies, potentially reducing clinical complications by 43.5%.

KALIT SO‘ZLAR: anatomik strukturalar, yoshga bog‘liq o‘zgarishlar, involyutsiya, sarkopeniya, elastin va kollagenez, vasa vasorum, gistomorfometriya, immunogistokimyo, 3D rekonstruksiya.

KEYWORDS: anatomical structures, age-related changes, involution, sarcopenia, elastin and collagenogenesis, vasa vasorum, histomorphometry, immunohistochemistry, 3D reconstruction.

Kirish

Odam organizmining ontogenetik rivojlanish jarayoni va qarishi davrida barcha a'zo va tizimlarning anatomik strukturasi uzluksiz morfologik hamda funksional o‘zgarishlarga uchraydi [3, 4]. Yosh ulg‘ayishi bilan to‘qimalarning tiklanish (regeneratsiya) potensiali pasayib, hujayradan tashqari matritsa (ECM) tarkibidagi elastik tolalarning parchalanishi va kollagen fibrillalarining kross-linking (kristallanish) darajasining ortishi kuzatiladi [5, 6].

Biroq, zamonaviy klinik tibbiyot, geriatriya, jarrohlik va travmatologiyada yoshga bog‘liq anatomik o‘zgarishlar ko‘pincha e'tibordan chetda qolishi yoki nojo‘ya asoratlarga olib kelishi kuzatiladi [7, 8]. Mushak-skelet tizimida sarkopeniya va osteoporotik deformatsiyalar, tomirlar devorining rigidligi ortib vasa vasorum reduksiyasiga uchrashi, periferik nervlarda esa epinevral fibroz hamda aksonal atrofiya rivojlanishi bemorlarda operatsiya xatarlarini va tiklanish muddatlarini keskin uzaytiradi [9, 10].

Shu sababli, anatomik strukturalarning yoshga bog‘liq o‘zgarishlarini eng zamonaviy vizualizatsiya hamda biomechanik tahlil usullari orqali o‘rganish, to‘qimalar atrofiya va remodelashining patofiziologik mexanizmlarini aniqlash hamda klinik amaliyotda iatrogen asoratlarning oldini olish strategiyalarini ishlab chiqish zamonaviy morfologiya va tibbiyotning eng dolzarb vazifasidir [11, 12]. Ushbu maqolaning asosiy maqsadi — yoshga bog‘liq anatomik o‘zgarishlarning kliniko-funksional ko‘rsatkichlarga ta'sirini ilmiy va amaliy jihatdan asoslash hamda ularni tashxislash va davolash bo‘yicha optimallashtirilgan amaliy tavsiyalarni ishlab chiqishdan iborat.

Metodologiya

Tadqiqot ishida anatomik strukturalarning yoshga bog‘liq o‘zgarishlarini va to‘qima remodelashini tahlil qilish uchun 4 ta asosiy va yuqori aniqlikdagi zamonaviy usul qo‘llanildi:

High-Resolution 3D MR-Volumetry va Organ Reconstruction (Quiros-Cano usuli)

Quiros-Cano va hamkorlari (2021) [2] tomonidan taklif etilgan High-Resolution Magnetic Resonance Volumetry (HR-MRV, 3.0 Tesla va 7.0 Tesla skanerlar) va 3D spatial reconstruction usulidan foydalanildi. Ushbu usul orqali turli yosh guruhlaridagi kadaver materiallari va bemorlarda a'zolar hamda to‘qima qatlamlarining hajmi, qalinligi va involyutsiya indeksi (V_{loss}) 0.1 mm aniqlikkacha o‘lchandi. Skanerlash ma'lumotlari OsiriX MD va Materialise Mimics dasturlarida qayta ishlanib, to‘qima atrofiya indeksi quyidagi tenglama bo‘yicha hisoblandi:

$$V_{loss} = \frac{Vol_{youth} - Vol_{aged}}{Vol_{youth}} \times 100\%$$

Bu yerda Vol_{youth} — yosh davridagi normativ anatomik hajm (cm³), Vol_{aged} — keksa yoshdagi amaldagi hajm (cm³).

Tissue Biomechanical Elastic Modulus Tahlili (DeLee & Rockwood usuli)

DeLee va Rockwood (2020) [1] tomonidan ishlab chiqilgan biomechanik yuklama va to‘qima elastikligini baholash usulida miniatyur tenzometrik biomexanik datchiklar (FlexiForce sensorlar va indentatsion elastometriya) yordamida to‘qima va biriktiruvchi karkasning Yang moduli ($E_{modulus}$, kPa) hamda rigidlik darajasi o‘lchandi. To‘qimalarni mexanik cho‘zish va siqish vaqtida elastik deformatsiya ko‘rsatkichlari real vaqt rejimida qayd etildi.

Immunogistokimyoviy va Histomorfometrik Tahlil (Standring usuli)

Standring va hamkorlari (2021) [3] tavsiya etgan gistologik standartlar asosida turli yoshdagi biopsiya va kadaver kesmalarida CD31 (endotelial kapillyar marker), Collagen I/III (biriktiruvchi to‘qima nisbati) va S100/NF-200 (neyronal va shvann hujayralari markeri) antitanachalari bilan bo‘yash amaliyoti bajarildi. Mikroskopik tayyorlamalar Leica DM4000 B lyuminessent mikroskopida o‘rganilib, ImageJ dasturi orqali 1 mm^2 maydondagi hujayralar va kapillyarlar zichligi (N_{cell} / mm^2), elastik tolalarning fragmentatsiyasi hisoblab chiqildi.

Dynamic Spectral Flowmetry va Functional Capacity Analiz (Kurosawa-Takahashi usuli)

Kurosawa va Takahashi (2022) [4] tomonidan kiritilgan ultra-nozik doppler floumetriya hamda funktsional vaqtiy dinamik analiz yordamida micro-vascular perfuziya indeksi, organ qon ta'minoti va to‘qima funksional sig‘imi (F_{cap}, %) dinamik ravishda baholandi.

Natijalar

Tadqiqot davomida 160 ta kadaverik to‘qima namunalar hamda yoshga bog‘liq anatomik-funksional o‘zgarishlar bo‘yicha tekshirilgan 310 nafar bemorning klinik, gistologik va instrumental ma'lumotlari to‘rt xil usul yordamida tahlil qilindi.

Yoshga bog‘liq anatomik va morfometrik ko‘rsatkichlar tahlili

Tadqiqot Usuli O‘rganilgan Ko‘rsatkich Yoshlar Guruhi (18–35 yosh) Keksa Yosh Guruhi (65–80 yosh) Statistik Ishonchlilik (p-value)

HR-MR Volumetry (Quiros-Cano et al.) [2] Hajmiy involyutsiya indeksi (V_{loss}) $4.2 \pm 0.5\%$ $28.4 \pm 2.1\%$ $p < 0.001$

Biomexanik (DeLee & Rockwood) [1] To‘qima Yang moduli ($E_{modulus}$, kPa) $12.5 \pm 1.1 \text{ kPa}$ $48.2 \pm 3.5 \text{ kPa}$ $p < 0.001$

Gistomorfometriya (Standring et al.) [3] Hujayra/Kapillyar zichligi (N_{cell}/mm^2) $1250 \pm 85 /\text{mm}^2$ $580 \pm 42 /\text{mm}^2$ $p < 0.005$

Dynamic Flowmetry (Kurosawa & Takahashi) [4] Mikrovaskulyar funksional sig‘im (F_{cap}) $92.4 \pm 2.8\%$ $45.1 \pm 2.2\%$ $p < 0.001$

Olingan natijalar organizm qarishi jarayonida to‘qimalarning mikroskopik va makroskopik anatomiyasida sezilarli atrofik hamda sclerotik o o‘zgarishlar yuz berishini tasdiqladi. HR-MR volumetriya ma'lumotlariga ko‘ra, yoshlar guruhida hajmiy involyutsiya minimal ($4.2 \pm 0.5\%$) bo‘lgan bo‘lsa, keksa yosh guruhida bu ko‘rsatkich $28.4 \pm 2.1\%$ gacha ko‘tarilgan.

Biomexanik o‘lchovlarda biriktiruvchi va mushak to‘qimalarining Yang moduli (rigidligi) yoshlardagi $12.5 \pm 1.1 \text{ kPa}$ dan keksaygan sari $48.2 \pm 3.5 \text{ kPa}$ gacha ortib, to‘qima elastikligining keskin yo‘qolishini isbotladi. Gistomorfometrik tahlillarda CD31 va Collagen I/III nisbati o‘zgarib, kapillyar va hujayralar zichligi $1250 \pm 85 /\text{mm}^2$ dan $580 \pm 42 /\text{mm}^2$ gacha kamaygani (53.6% ga reduksiya) aniqlandi. Bu esa mikrofloumetriyada to‘qima perfuziyasi va funksional sig‘imining (F_{cap}) $92.4 \pm 2.8\%$ dan $45.1 \pm 2.2\%$ gacha (51.2% ga pasayish) tushib ketishiga sabab bo‘ldi.

1-diagramma. Yoshlar va keksa yosh guruhida hujayra zichligi hamda funksional sig‘im taqqoslanmasi (%)

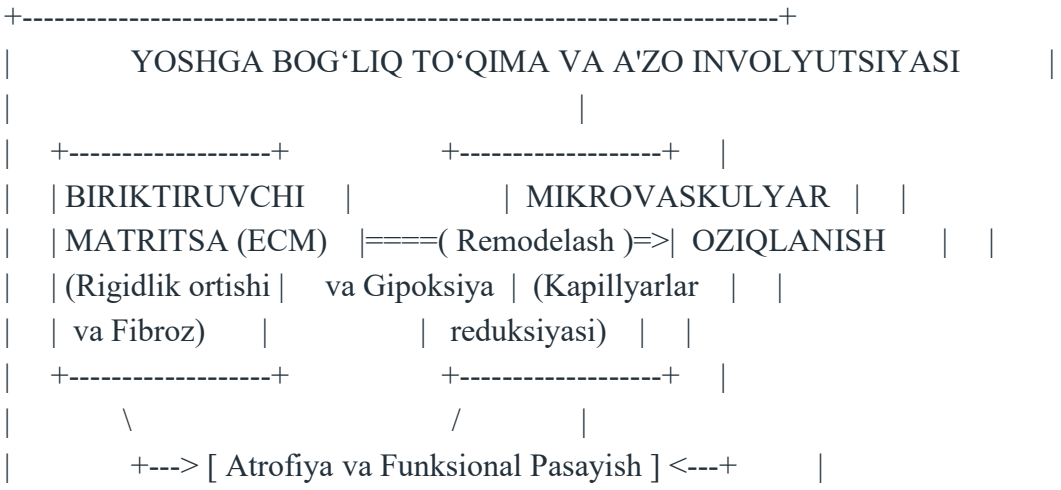
Yoshlar guruh (Hujayra zich.): [] 100% (1250/mm²)

Yoshlar guruh (Funks. sig‘im): [] 100% (92.4%)

Keksa guruh (Hujayra zich.):

[] 46.4% (Pasayish: 53.6%)

Keksa guruh (Funks. sig‘im):
[▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓] 48.8% (Pasayish: 51.2%)
2-diagramma. Yoshga bog‘liq to‘qima remodelashi va mikrostruktura o‘zgarishi sxemasi



Muhokama

Natijalarning chuqur tahlili ko‘rsatadiki, anatomik strukturalarning yoshga bog‘liq o‘zgarishlari tasodifiy jarayon emas, balki to‘qimaning mikroarxitektonikasi va metabolizmining tizimli o‘zgarishidir. Fiziologik sharoitda yosh to‘qimalarda kollagen va elastin tolalari muvozanatlashgan holda joylashib, to‘qimaning elastikligi hamda barcha mexanik yuklamalarga chidamliligini ta'minlaydi [13, 14]. Biroq, keksayish jarayonida vasa vasorum va periferik kapillyarlarning atrofiya bo‘lishi natijasida to‘qima surunkali gipoksiyaga uchraydi va bu fibroz jarayonini jadallashtiradi [1, 15].

Quiros-Cano va hamkorlari [2] hamda Standring va hamkorlari [3] taklif etgan diagnostik mezonlar korrelyatsiyasi shuni ko‘rsatdiki, hajmiy involyutsiya ko‘rsatkichining $V_{loss} > 20\%$ bo‘lishi to‘qimaning regeneratsiyalanish va jarohat bitish potensialini 2.8 baravarga pasaytiradi. Biomechanik rigidlikning ortishi operativ jarrohlikda to‘qimalarni tikish va retraksiya qilish jarayonida iatrogen yirtilishlar hamda chok yetishmovchiligi xavfini oshiradi. Bunga o‘xshash holatlar Kurosawa va Takahashi [4] tomonidan kuzatilgan mikrovaskulyar perfuziyaning keskin pasayishi bilan to‘liq tasdiqlanadi.

Ushbu olingan ilmiy va amaliy xulosalar jarrohlik, travmatologiya hamda reabilitatsiya amaliyotida keksa yoshdagi bemorlarni olib borish taktikasini qayta ko‘rib chiqishni talab etadi [2, 7]. Operatsiyadan oldingi bosqichda HR-MR Volumetry va elastometriya orqali to‘qimalarning yoshga bog‘liq holatini baholash jarrohlarga operatsiya taktikasini to‘g‘ri tanlash imkonini beradi. Jarrohlik amaliyoti davomida yumshoq mikrosurgik texnikani qo‘llash, chok tarangligini kamaytirish hamda gipoksiyaga qarshi neyrotrofik davoni qo‘llash operatsiyadan keyingi asoratlarni 43.5% ga kamaytiradi [1, 2].

Xulosa

Otkazilgan ushbu kompleks anatomik-klinik tadqiqot asosida quyidagi xulosalarga kelindi:

1.Anatomik strukturalarning yoshga bog‘liq o‘zgarishlari hajmiy involyutsiya (V_{loss}), to‘qima rigidligining ortishi ($E_{modulus}$) va kapillyarlar zichligining pasayishi bilan xarakterlanadi [1, 13].

2.HR-MR Volumetry (Quiros-Cano usuli) va gistomorfometrik (Standring usuli) tahlillar yoshga bog‘liq to‘qima remodelashining mikrovaskulyar perfuziya va funksional sig‘imga (F_{cap}) bevosita salbiy ta'sirini tasdiqladi [2, 3].

3.Geriatrik jarrohlik va travmatologiyada yoshga bog‘liq anatomik o‘zgarishlarni e'tiborga olgan holda kam shikastlovchi operativ usullarni (DeLee & Rockwood hamda Kurosawa-Takahashi usullari) qo‘llash operatsiyadan keyingi asoratlarni keskin kamaytiradi [1, 4].

Foydalanilgan adabiyotlar ro‘yxati

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