QON GLYUKOZASI GOMEOSTAZINI BOSHQARISHDA INSULIN VA GLUKAGONNING DINAMIK MUVOZANATI

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Annotatsiya: *Glyukozaning homeostazini saqlash inson metabolizmining markaziy mexanizmlaridan biridir. Ushbu maqolada insulin va glukagon gormonlarining o‘zaro ta’siri, ularning jigar, mushak va yog‘ to‘qimalaridagi metabolik jarayonlarga ta’siri hamda bu muvozanatning buzilishi diabet, semirish va endokrin kasalliklarda qanday rol o‘ynashi tahlil qilinadi. So‘nggi yillardagi (2015–2025) molekulyar va fiziologik tadqiqotlar ushbu ikki gormon o‘rtasidagi “qarama-qarshi hamkorlik” printsipining murakkabligini ochib berdi. [1]*

Kalit so‘zlar: *Insulin, glukagon, glyukoza homeostazi, metabolik muvozanat, pankreas, diabet, energiya almashinuvi, gormonal regulyatsiya.*

Tadqiqot maqsadi: Tadqiqotning asosiy maqsadi — insulin va glukagonning glyukoza darajasini barqaror saqlashdagi o‘zaro bog‘liqligini, ular o‘rtasidagi fiziologik teskari aloqa mexanizmlarini hamda gomeostatik buzilishlarning klinik oqibatlarini aniqlash. [2]

Tadqiqot uslublari: Maqolani tayyorlashda systematic literature review yondashuvi asosida PubMed, ScienceDirect, MDPI, Frontiers, va IntechOpen bazalarida 2015–2025-yillarda chop etilgan 20 dan ortiq maqola tahlil qilindi. Ma’lumotlar tahlilida endokrin modellar, glyukozani sezuvchi hujayra mexanizmlari va pankreatik orolchalar faoliyati haqidagi tajribalar asos bo‘ldi. [3]

Kirish

Glyukoza inson organizmida asosiy energiya manbai bo‘lib, miya, mushak va boshqa to‘qimalar faoliyati uchun zarur modda hisoblanadi. Qon glyukozasining miqdori qat’iy chegaralarda saqlanib turadi — bu holat glyukoza gomeostazi deb ataladi. Ushbu muvozanatning asosiy regulyatorlari — insulin va glukagon gormonlaridir. [1]

Insulin, oshqozon osti bezining β-hujayralari tomonidan ishlab chiqariladi va u glyukozani hujayralarga kirishini ta’minlaydi, jigar va mushaklarda glikogen shaklida saqlanishini rag‘batlantiradi. Aksincha, glukagon α-hujayralar tomonidan ajralib chiqadi va qondagi glyukoza miqdori pasayganda jigar orqali glikogenoliz va glyukoneogenezni faollashtirib, glyukozaning qon oqimiga qaytishini ta’minlaydi. [2]

So‘nggi yillarda (2015–2025) o‘tkazilgan molekulyar-biokimyoviy tadqiqotlar ushbu ikki gormonning o‘zaro aloqasi faqat “qarama-qarshi” emas, balki dinamik muvofiqlashtiruvchi tizim ekanligini ko‘rsatdi. [3] Bu tizimda insulin va glukagon nafaqat glyukoza darajasiga, balki markaziy asab tizimi, ichak mikrobiotasi, adipokinlar va boshqa gormonlar signallariga ham javob beradi. [4]

Shuningdek, Anastasiou et al. (2025) tomonidan olib borilgan tadqiqotlarda insulin-glukagon balansining buzilishi semizlik, metabolik sindrom va 2-tur diabetning rivojlanishida muhim rol o‘ynashi aniqlangan. [5] Shu bois, ushbu maqola insulin va glukagon o‘rtasidagi dinamik muvozanatning fiziologik va molekulyar asoslarini, uning buzilish mexanizmlarini hamda klinik ahamiyatini tahlil qilishga bag‘ishlanadi.

Natijalar

So‘nggi o‘n yillikda olib borilgan ilmiy tadqiqotlar insulin va glukagon o‘rtasidagi dinamik muvozanatning murakkab ko‘p darajali boshqaruv tizimiga ega ekanini ko‘rsatdi. Bu tizimning asosiy komponentlari — pankreatik orolchalar, jigar, mushak to‘qimalari, yog‘ hujayralari, hamda asab va ichak-endokrin tizimi hisoblanadi. [1]

1. Gormonlararo o‘zaro ta’sir mexanizmi

Insulin va glukagon o‘rtasidagi o‘zaro ta’sir mexanizmi glyukoza gomeostazini saqlashda markaziy o‘rin tutadi. Ularning sekretsiyasi teskari aloqa printsipi asosida boshqariladi: qondagi glyukoza miqdori oshganda insulin sekretsiyasi ortadi, glukagon sekretsiyasi esa kamayadi; glyukoza pasayganda esa buning aksi kuzatiladi. Ushbu “qarama-qarshi hamkorlik” mexanizmi orqali organizm energiya balansini optimal holatda ushlab turadi. [1]

β- va α-hujayralar o‘rtasidagi signal almashinuvi

Oshqozon osti bezining Langerhans orolchalarida joylashgan β-hujayralar (insulin ishlab chiqaruvchilar) va α-hujayralar (glukagon ishlab chiqaruvchilar) bir-biriga bevosita parakrin signal orqali ta’sir qiladi. β-hujayralar tomonidan ajratilgan insulin va GABA α-hujayralarda glukagon sekretsiyasini tormozlaydi. Shu bilan birga, α-hujayralar tomonidan ajraladigan glukagon β-hujayralarda GLP-1 reseptorlari orqali insulin ishlab chiqarilishini rag‘batlantiradi. [2][3]

Molekulyar darajadagi mexanizmlar

So‘nggi yillarda olib borilgan molekulyar tadqiqotlar ushbu jarayonda ko‘plab signal kaskadlar ishtirok etishini ko‘rsatmoqda. You et al. (2026) tomonidan o‘tkazilgan tadqiqotda SRSF1 oqsili β-hujayralarning proliferatsiyasida va insulin sekretsiyasi barqarorligida muhim rol o‘ynashi aniqlangan. Bu oqsil PI3K/Akt va mTOR yo‘llarini faollashtirib, hujayra metabolizmini tartibga soladi. [4]

Gormonlararo muvozanatning buzilishi

Insulin-glukagon nisbati buzilganda (masalan, diabet yoki semizlik holatlarida) α-hujayralar giperglukagonemiya holatiga o‘tadi, bu esa jigar orqali glyukoneogenezni orttiradi. Shu bilan birga, insulin signalizatsiyasining pasayishi jigar va mushaklarda glikogen saqlanish jarayonini susaytiradi, natijada giperglikemiya rivojlanadi. [5][6]

Fiziologik muvofiqlashtirish

Sog‘lom organizmda insulin va glukagon faolligi jigar, mushak va yog‘ to‘qimalari tomonidan muvofiqlashtiriladi. Masalan, mushak to‘qimalarida insulin glyukoza tashuvchi (GLUT-4) oqsillarni faollashtiradi, yog‘ to‘qimalarida esa lipogenezni rag‘batlantiradi. Glukagon esa jigarda glikogenolizni faollashtirib, glyukoza chiqarilishini ta’minlaydi. Shu tarzda, ikkala gormonning o‘zaro muvofiqlashtirilgan ta’siri metabolik moslashuvchanlikni ta’minlaydi. [7][8]

2. Mikrobiota va glukagon sekretsiyasi

Hareesha et al. (2025) ishida antibiotiklar ta’sirida ichak mikrobiotasining o‘zgarishi α-hujayralar faoliyatiga bevosita ta’sir qilishi aniqlangan. Probiotiklar orqali mikrobiota muvozanatini tiklash natijasida glukagon sekretsiyasi normallashgani, bu esa glyukozaning fiziologik darajada ushlab turilishiga yordam bergani kuzatilgan. [3]

3. Energiya almashinuvi va insulin sezuvchanligi

Anastasiou et al. (2025) tomonidan o‘tkazilgan klinik tadqiqotda bariatrik jarrohlikdan so‘ng gormonlar nisbati tubdan o‘zgarib, insulin sezuvchanligi 40% gacha oshgani aniqlangan. Bu natija gormonlar o‘rtasidagi nisbiy muvozanat tiklanishining metabolik sindromni kamaytirishdagi muhimligini tasdiqlaydi. [4]

4. Diabet va gormonlar disbalansi

Mohandass (2025) tomonidan qayd etilganidek, 2-tur diabetda α-hujayralar glukozaga nisbatan rezistent bo‘lib qoladi, bu esa ortiqcha glukagon sekretsiyasiga va doimiy giperglikemiyaga olib keladi. Shu sababli, zamonaviy davolash strategiyalari (GLP-1 agonistlari va SGLT2 inhibitörlari) insulin-glukagon balansini tiklashga qaratilmoqda. [5]

5. Oziqlanish va vaqtli ochlik (fasting) ta’siri

Drăgoi et al. (2025) tomonidan olib borilgan tizimli tahlilda vaqtli ochlik (intermittent fasting) insulin darajasini kamaytirib, glukagon faolligini vaqtincha oshirishi orqali energiya sarfini optimallashtirishi aniqlangan. Bu natija energiya almashinuvi jarayonlarini tabiiy ravishda muvozanatlashtirishga yordam berishi mumkinligini ko‘rsatadi. [6]

6. Neyro-gormonal boshqaruv

Verma (2025) va Sapovadia (2025) tadqiqotlariga ko‘ra, markaziy asab tizimi, xususan, gipotalamus, pankreatik orolchalar bilan neyroendokrin bog‘lanish orqali insulin va glukagon sekretsiyasini muvofiqlashtiradi. Neyropeptid Y va GABA tarmoqlari bu jarayonda markaziy rol o‘ynaydi. [7][8]

7. Umumiy natijaviy xulosa

Tahlil qilingan ma’lumotlar shuni ko‘rsatadiki, insulin va glukagonning o‘zaro bog‘liq sekretsiyasi — nafaqat endokrin, balki ko‘p organli tizimli regulyatsiya jarayonidir. U markaziy asab tizimi, mikrobiota, gormonlar va hujayra ichidagi signal yo‘llar bilan chambarchas bog‘liq. Ushbu muvozanatning buzilishi esa diabet, semizlik va metabolik sindromning rivojlanishida hal qiluvchi rol o‘ynaydi. [9]

Muhokama

Gormonlar o‘rtasidagi dinamik muvozanatning buzilishi glyukoza homeostazini bevosita izdan chiqaradi. Insulin yetishmovchiligi yoki glukagon ortiqligi giperglikemiyani keltirib chiqaradi, buning natijasida jigar glyukoneogenez yo‘liga o‘tadi. [9]

So‘nggi yillarda ushbu mexanizmlarni tiklashga qaratilgan terapevtik yondashuvlar, jumladan, GLP-1 agonistlari, probiotiklar va intermittent fasting strategiyalari samarali natija bergani qayd etilgan (Drăgoi et al., 2025 [10]; Verma, 2025 [11]).

Gormonlar o‘rtasidagi bu “gomeostatik raqs” tananing energiya muvozanatini saqlab turadi va bu tizimning nozik buzilishi metabolik kasalliklarning asosi sifatida qaralmoqda.

Xulosa

Insulin va glukagonning o‘zaro ta’siri — organizmda glyukoza gomeostazini ta’minlovchi murakkab tarmoqning markaziy elementi. Ushbu ikki gormon o‘rtasidagi dinamik muvozanatni tushunish diabet, semizlik va boshqa endokrin buzilishlarning molekulyar asoslarini chuqurroq o‘rganishga imkon beradi. So‘nggi tadqiqotlar bu tizimning markaziy asab tizimi, mikrobiota va hujayra signal yo‘llari bilan uzviy bog‘liqligini ko‘rsatmoqda. [12]

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