Doctor 022

Histology

Sheet no.

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Smooth Muscle

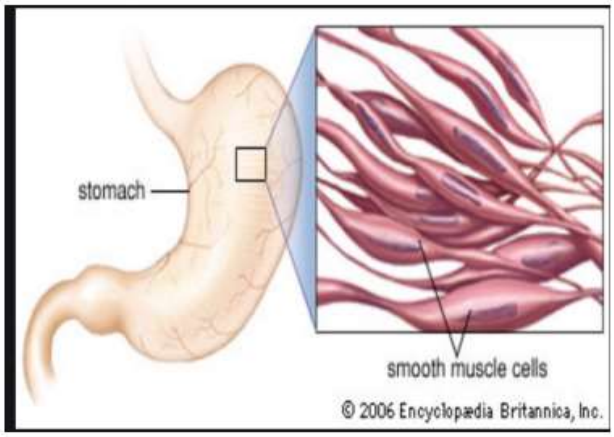
Mostly the sheet is from the doctor speech & you find that in black

We know that skeletal and cardiac muscles share the concept of striation, it means the presence of Z discs; where thin filaments bind directly & thick filaments bind indirectly.

Although smooth muscles contain thin & thick filaments that slide & contract, they are unstriated (have no Z disc) so they're unique.

SMOOTH MUSCLE

- Slow and steady contraction
- Under the control of autonomic nerves and various hormones.
- Present in blood vessels, digestive, respiratory, urinary, and reproductive tracts.
- Fibers of smooth muscle are elongated, tapering, and unstriated cells.
- Enclosed by an endomysium (a network of type I and type III).
- Length is 20 µm - 500 µm.



Comparing smooth with skeletal

Skeletal has more myofilaments so it has forceful contraction, but smooth muscle has less myofilaments; because of the slow & semi contraction. Here we don't need forceful contraction.

Who make body building, what happen to his cells?

Answer is hypertrophy, it means that diameter of muscle fibers increase because muscle cells synthesise more myofibrils to contract.

Why some people get tired while going up stairs but others don't? It's because their myocytes in heart not strong enough to keep pumping through movement. To over come this and other muscles problem you have to do cardio exercise and have a protein rich diet which provide

nutrition for myofibrils to have healthy muscular tissue. How would this reflect on myocytes? Myofibrils would increase in amount & contraction increase, but fluid doesn't increase.

Smooth has myofibrils which move throughout the day while GI tract digest &mix food with enzymes. It moves in peristatic movement to push food forward & finally defecate it. Then we repeat the cycle; so we need slow not forceful contraction.

Autonomic control

Smooth work under the control of autonomic nerves (nothing in voluntary). Body also use hormones to make contraction; like in uterus regulation by oxytocin hormone leads to contract smooth muscles to deliver the embryo outside.

Stretching

Smooth muscles have spindle elongated unstriated shape. As you can see central located nucleus in both (cardiac & smooth cells).

Each smooth enclosed by an external lamina & a network of type 1 & type 3 collagen fibers compressing the endomesium.

this sentence is from the book

Type three is the major while collagen type one is minor.

Smooth has length from 20 to 500(huge range is duplicated 25 times). In uterus it's function to house growing baby, so uterus become larger when embryo grow. Good percentage of smooth muscles -during pregnancy- become longer & stretching happens, also the number of smooth muscle cells increases. (Hyperplasia) is a term means physiological increasing in number, occurs normally without any side effect & we need it. On contract; cancer cells & tumours have uncontrolled pathological increase in number. There is no expression of what happens; we just know that some genes are damaged and still dividing and spreading through neighbouring tissues without control.

Increasing hormones & growth factors, increasing stretching happen when where we needed hyperplasia.

Action potential

In skeletal we talked about contraction & axon which come from nerve, eventually from axon terminals that holding with sarcolemma. (We called this structure a neuromuscular junction). We said that vesicles from the axon terminals open to release neurotransmitter to bind with the receptor on the sarcolemma, then we translate neuro impulse into action potential in muscle; but this perfect structure doesn't exist in smooth muscles.

Axon of Autonomic nerves passing through smooth muscle have periodic swelling or varicosities that lie in close contact with smooth fibers.

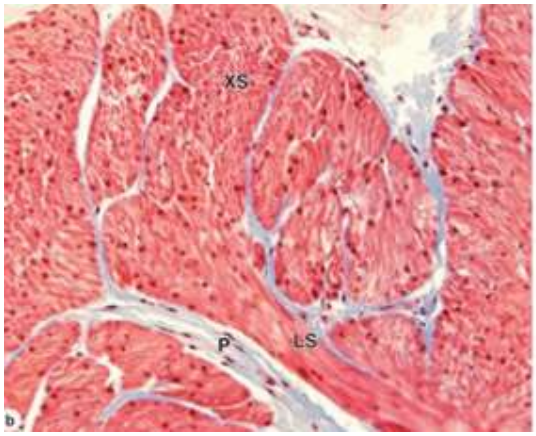
sentence from the book also the doctor has mentioned this in the lecture

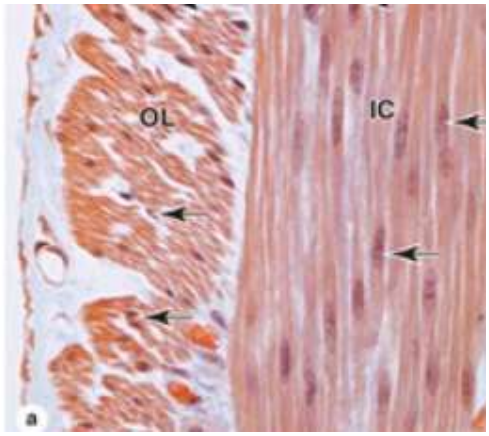
Vesicles release neurotransmitters to smooth muscles but not all of them bind to neurotransmitter, and not all of them get action potential when the neuro impulse arrive. So, how we make them contract?

SMOOTH MUSCLE

- Lack well-defined neuromuscular junctions
- Axons of autonomic nerves have periodic swellings close to muscle fibers----synaptic vesicles-----acetylcholine o norepinephrine---binds receptors in many muscle cells.
- Stimulation is propagated via gap junctions------contract synchronously
- Fibroblast activity!!!

If one group of cells had action potential they spread the action to the rest cells through ***gap junctions***. Smooth seem hybrid between cardiac & skeletal; they have neuromuscular but it not will defined them; & they have gap junctions like cardiac ones. & that's how these cells get the contraction.





If we look at smooth muscle cells under the microscope they look like fibroblasts. You can't actually distinguish them easily (later on lab lectures we could say smooth muscles could be fibroblasts unless we know this is a layer of smooth muscles. To distinguish them they use immunostaining (distinguishing between muscles & fibroblasts pictures isn't required from students in exam).

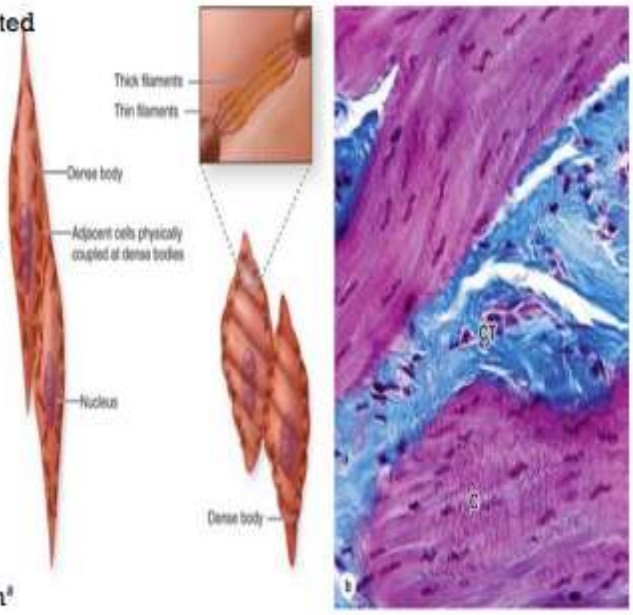
Fibroblast activity in smooth muscle means that it has the ability to synthesise & release fibers & other ground substances like glycoproteins & proteoglycans, because fibroblasts is the type that can synthesise & release fibers. As well as osteoblasts & chondroblasts - from connective tissue cells- are capable to do this function.

Dense bodies

Smooth muscle isn't striated due to absence of Z discs; so thin & thick filaments needed something instead to hold them (a dense body). Dense bodies are globular structures in the cytoplasm & they have sarcolemma attachments.

Contraction

- Dense bodies (similar to Z discs) plasmalemma-associated attach to thin filaments.
- Thin and thick myofilaments crisscross the sarcoplasm obliquely
- Mitochondria, glycogen granules, and Golgi complexes located centrally near nucleus.
- Rudimentary sarcoplasmic reticulum
- Rich in gap junction
- Caveolae are small plasmalemma invaginations which contain signaling components.
- Ca^{2+}: Calmodulin and Ca2+-sensitive myosin light-chain kinase (MLCK)



In smooth muscle actin filaments insert into anchoring cytoplasmic & plasmalemma -associated dense bodies which contain a-actinin & are functionally similar to Z discs of striated & cardiac muscle. Smooth muscle cells also have an elaborate array of 10-nm intermediate filaments, composed of desmin, which also attach to dense bodies.

this sentence is from the book

Smooth cells have relaxed elongated spindle shape ,with nucleus inside that is surrounded by organelles such as: some mitochondria, some Golgi apparatus, some glycogen & some of sarcoplasmic reticulum.

Thin & thick running obliquely on the long axes of the cell & (long axes) is the direction of myofibrils.

The groups of filaments are attached to dense bodies which spread widely among the cell. So when these muscles slide they contract from all direction so they shorten & become more rounded. It looks like it become more in width but significantly shorter in length.

Srcoplasmic Reticulum

The fibers have rudimentary sarcoplasmic reticulum, but lack T-tubules; their function is unnecessary in these smaller, tapering cells with many gap junctions.

this sentence is from the book

Sarcoplasmic reticulum rudimentary is less in smooth cells, unlike the skeletal which has very developed reticulum, also cardiac seem to have less developed reticulum than skeletal ones. Why??

When we have too much myofibrils we need a lot of calcium (Ca); so sarcoplasmic is large and exist around T-tubules. Sarcoplasmic reticulum (SR) in skeletal muscle is: well developed, with two terminal cisterns per sarcomere in triads with T tubule. *sentence from the book*

In skeletal there triads surrounded by tubules which increase complexity in the structure.

In heart there myocytes & less myofibrils; so SER (Ca storage) is less developed in smooth than skeletal so it's contraction is less & we use(rudimentary) term which means few, simple & less developed.

Also SER in atria is less than in ventricles -as doctor said-.

SR in cardiac is: less well-developed, one small terminal cistern per sarcomere in dyad with T tubule. *sentence from the book*

In smooth there are no T tubules, there caveolae (invagination) like small depression that help to accelerate the spread of action potential to make Ca binding.

Caveolae of smooth muscle cells contain the major ion channels that control Ca release from sarcoplasmic cisternae at myofibrils which initiate contraction. *sentence from the book*

Remember in skeletal & cardio myocytes Ca were bind with troponin which is attached to tropomyosin so Ca made conformational changes. & myosin binding sites were exposed. So myosin was ready and bound

to ATP. Then we grab thin with thick filaments & sliding happened; eventually contraction. Instead of troponin we have calmodulin & Ca sensitive MLCK which is myosin light chain kinase to produce contraction.

Regeneration

(The last topic in muscle tissue). Why we discuss it in every tissue? Because it's very important. So far when we talked about connective & epithelium have good regeneration. But in connective tissue it special types there were differentiation, such in cartilage which has low generation; cells with perichondrium have better regeneration than cells without it.

REGENERATION OF MUSCLE TISSUE

- In **skeletal muscle**, although the multinucleated cells cannot undergo mitosis
- Mesenchymal satellite cells lying inside the external lamina can participate in limited regeneration.
- **Cardiac muscle** lacks satellite cells
- very little regenerative capacity beyond early childhood.
- Defects or damage replaced by proliferating fibroblasts and CT formation leading to myocardial scars.
- **Smooth muscle** is capable of a more active regenerative response.
- Can undergo mitosis and replace the damaged tissue.

Now, how muscles regenerate?

Regeneration comes from satellite (progenitor) cells. The source of regenerating cells is the sparse population of mesenchymal satellite cells lying

inside the external lamena of each muscle fiber. Satellite cells are inactive, reserve myoblast -active cells- that persist after muscle differentiation. *sentence from the book*

Myoblast from stem cells merge to give myotubes and in further differentiation it give muscle fibers.

When satellite cells activated they called myoblasts and they become able to divide. All this happen because muscle fibers can't divide; you grow with the number you have. You're born with the number of myocytes you have they very low in number ,& they can't divide.

As we said who make body building not just has hypertrophy; but also his satellite cells may increase in number but number still limited; so if you have significant damage or lose muscle fibers satellite cells can't be repaired. Maybe there will be very limited repairing by muscle tissue, but repair mainly -in significant damage- will be a scar tissue that comes from fibroblast in muscle tissue. Fibroblast also gave endomysium, perimysium, epimysium & fascia.

Every where in our body we have fibroblasts (making scar), that's a way to repair something, it's not perfect but we need them to repair.

Skeletal muscle has moderate regeneration, But smooth muscle has better regeneration than skeletal, Why???

As we said in uterus in pregnancy they can divide; & anything can divide has great regeneration. Smooth is on the top in regeneration while cardiac unfortunately is the worst in regeneration. Cardiac don't have satellite cells, however is it give a zero hope & no generation will happen?? No, there is hope.

Regeneration with age

The younger you're the regeneration is better. Satellite cells won't still dormant throughout your life' you lose some of them through years.

Your heart when you're younger has better regeneration; diseases increase when older you get.

Research will get the solution

Throughout studies researchers found good regeneration in some animals like mice, particularly in young ones. With researching we will find ways to fix damaged cardio myocytes.

If we compare between living creatures would like to survive versus what like to become vanished & extinct. We observe that elephants not good to survive because they're extremely large so can't protect themselves . But mice & insects would survive because they're small, so how we still alive?? The smarter you're & sometimes the smaller you're help to still alive. Large& dump animals -which aren't smart enough to protect themselves- like koala go to extinct.

On contract, mice are extremely brilliant (know how to survive), so in studies we almost have mice. Surprisingly 97% of there genes are identical to ours. The idea isn't in the number but in which genes are on, which ones are functional; & their environment & food is different from ours. Finally our being is concerned with environment, genes & how they integrate the living creatures differ from each other.

According to heart, somehow we can replicate using mice cells to repair damages; when still dying because of heart attack we can fix that for you & repopulate. Whatever the solution is we'll find. Just such when we became able to produce insulin from bacteria & to cure cancer.

Can we lose our heart cells? Yes in cause of elderly , bad genes, diet or physical activities; almost you can check yourself.

Heart diseases is almost related to blood vessels diseases. Arteriosclerosis happen when blood rich with fats & cholesterols move in arteries it sediments cholesterol, causing decreasing in diameter, that causes attack ,in coronary arteries which go to heart represent major arteries give smaller branches. The bigger the block the bigger

the problem, so blood doesn't reach number of cells leading to lack oxygen & nutrition in that cells so cells die forming necrotic tissue has no satellite cells so nothing can fix. As a result the body isolate this tissue & immune cells come to clean the place from disease, but the place won't become empty; we put a scar tissue. So we will have muscle tissue filled with collagen type 1, the more the affected region the slower the movement of people who had heart attack because their heart isn't strong enough to pump blood.

''BE A WARRIOR NOT A WORRIER''

QUOTE FROM ELIZABETH ARCHER