Muscular System

Prof. Dr. Malak A. Al-yawer Department of Anatomy/Embryology Section

At the end of this lecture, the medical student will be able to

- State the embryonic origin of skeletal muscle
- Distinguish between somitomeres and somites
 - Define mesodermal domains of the embryo
 - Define lateral somitic frontier

 \triangleright

- State the embryonic significance of the lateral somitic frontier for the development of dermis and ribs
 - Describe the embryonic origin of innervation of myotomes
 - State the new and old concepts of muscle development
 - Define myogenesis & list their steps
 - Define patterning of muscles
 - State the embryonic origins of head musculature
 - State the embryonic origin of limb musculature
 - Describe the embryonic origin of cardiac muscles
 - Describe the embryonic origin of smooth muscles
 - State some clinical correlates

Skeletal muscle

is derived from paraxial mesoderm, which forms somites from the occipital to the sacral regions and somitomeres in the head.



Somitomeres



- seven in number
- are partially segmented whorls of mesenchymal cells derived from paraxial mesoderm.
- remain loosely organized structures and never segregate into sclerotome and dermomyotome segments.

Somites



- initially form as somitomeres
- extend from the occipital region to the tail bud.
- Immediately after segmentation, these somitomeres undergo a process of epithelization and form a "ball" of epithelial cells with a small cavity in the center

The ventral region of \Box each somite form sclerotome for the vertebrae and ribs. Cells in the upper region \Box of the somite form dermatome and two muscle-forming areas at the ventrolateral (VLL) and dorsomedial (DML) lips (or edges).





- Cells from the DML & VLL form progenitor muscle cells ventral to the dermatome to form dermomyotome
- Some cells from the ventrolateral region migrate into the adjacent parietal layer of the lateral plate mesoderm

Lateral somitic frontier

- a well-defined border between each somite and the parietal layer of lateral plate mesoderm
- This frontier separates two mesodermal domains in the embryo:
- (1) Primaxial domain comprises the region around the neural tube and contains only somite-derived (paraxial mesoderm) cells
- (2) Abaxial domain consists of the parietal layer of lateral plate mesoderm together with somite cells that have migrated across the lateral somitic frontier.



- **Abaxial domain** form infrahyoid,
- abdominal wall (rectus abdominus, internal and external oblique, and transversus abdominus),
 - limb muscles.
 - Primaxial domain form
 - muscles of the back, ✓
 - shoulder girdle \checkmark
 - intercostal muscles.√

Origins of Muscles From Abaxial and Primaxial Precursors

	Primaxial	Abaxial	
Cervical region	Scalenes	Infrahyoid	
	Geniohyoid		
	Prevertebral		
Thoracoabdominal region	Intercostals	Pectoralis major and minor	
		External oblique	
		Internal oblique	
		Transversus abdominus	
		Sternalis	
		Rectus abdominus	
		Pelvic diaphragm	
Upper limb	Rhomboids	Distal limb muscles	
	Levator scapulae		
	Latissimus dorsi		
Lower limb ^a		All lower limb muscles	
^a The precise origin of muscles in the pelvic region and lower limb has not been determined, but most if not all are abaxial in origin.			

Muscle cell precursors



- Abaxial muscle cell of precursors receive many of their signals for differentiation from lateral plate mesoderm
- Primaxial muscle cell precursors receive many of their developmental signals from the neural tube and notochord.

The lateral somitic frontier

- It defines the border of dermis derived from dermatomes in the back and dermis derived from lateral plate mesoderm in the body wall.
 - It defines a border for rib development with the bony components of each rib derived from primaxial sclerotome cells and the cartilaginous parts of those ribs derived from abaxial sclerotome cells.

Regardless of their domain, each myotome receives its innervation from spinal nerves derived from the same segment as the muscle cells.

The new description of muscle development differs from the old concept



- The new description of muscle development characterized by primaxial and abaxial domains (based on the actual embryological origin)
- The old concept of epimeres (back muscles) and hypomeres (limb and body wall muscles), which was based on a functional definition of innervation)
 - **Epimeric (epiaxial) muscles** were innervated by dorsal primary rami;
- hypomeric (hypaxial) muscles by ventral primary rami

Myogenesis (muscle formation)

- Myoblasts: primordial muscle cells
- Myotubes is formed by fusion of myoblasts to form elongated, multinucleated, cylindrical structuresmyotubes.
- myofilaments develop in the cytoplasm of the myotubes.
- ✓ By the end of the3rd month , crossstriations, typical of skeletal muscle, appear.
- As the myotubes develop, they become invested with external laminae
- ✓ Fibroblasts produce the perimysium and epimysium
- ✓ the endomysium is formed by the external lamina, and reticular fibers.



Tendons of muscles

 are derived from sclerotome cells lying adjacent to myotomes at the anterior and posterior borders of somites. **PATTERNING OF MUSCLES** are controlled by connective tissue into which myoblasts migrate.

- In the head region, these connective tissues are derived from neural crest cells;
- in cervical and occipital regions, they differentiate from somitic mesoderm; and
- □ in the body wall and limbs, they originate from the **parietal layer of lateral plate mesoderm**.

HEAD MUSCULATURE

 All voluntary muscles of the head region are derived from paraxial mesoderm (somitomeres and somites)



Table showing the origin of craniofacial muscles

Mesodermal Origin	Muscles	Innervation
Somitomeres 1 and 2	Superior, medial, ventral recti	Oculomotor (III)
Somitomere 3	Superior oblique	Trochlear (IV)
Somitomere 4	Jaw closing	Trigeminal (V)
Somitomere 5	Lateral rectus	Abducens (VI)
Somitomere 6	Jaw opening, other second arch	Facial (VII)
Somitomere 7	Stylopharyngeus	Glossopharyngeal (IX)
Somites 1 and 2	Intrinsic laryngeals	Vagus (X)
Somites 2 to 5ª	Tongue	Hypoglossal (XII)
^ø Somites 2 to 5 constitu	ute the occipital group (somite 1 deger	nerates for the most part).

LIMB MUSCULATURE

- The first indication of limb musculature is observed in the 7th week of development as a condensation of mesenchyme near the base of the limb buds.
- The mesenchyme is derived from dorsolateral cells of the somites that migrate into the limb bud to form the muscles



CARDIAC MUSCLE

- Cardiac muscle develops from splanchnic mesoderm surrounding the endothelial heart tube.
- Myofibrils develop as in skeletal muscle, but myoblasts do not fuse.

Late in the embryonic period, Purkinje fibers form which are special bundles of muscle cells develop with relatively few myofibrils and relatively larger diameters than typical cardiac muscle fibers.

SMOOTH MUSCLE

- Smooth muscles in dorsal aorta and large arteries: derived from lateral plate mesoderm and neural crest cells.
- Smooth muscle in coronary arteries, originates from **proepicardial cells and neural crest cells**.
- Smooth muscle in the wall of the gut and gut derivatives is derived from the splanchnic layer of lateral plate mesoderm
- Only the sphincter and dilator muscles of the pupil and muscle tissue in the mammary and sweat glands are derived from **ectoderm**.

Poland sequence

- Partial or complete absence of a muscle is common.
- Poland sequence is characterized by absence of the pectoralis minor and partial loss of the pectoralis major (usually the sternal head) muscles



Prune belly syndrome

- Is partial or complete absence of abdominal musculature. Usually, the abdominal wall is so thin that organs are visible and easily palpated.
- This defect is associated with malformations of the urinary tract and bladder, including urethral obstruction.



Muscular dystrophy

- a group of inherited muscle diseases that cause progressive muscular wasting and weakness.
- There are a large number of these types of diseases of which Duchenne's muscular dystrophy (DMD) is the most common. The disease is inherited as X-linked recessive such that males are much more often affected than females.

Congenital Torticollis(wry neck)

- result from tearing of fibers of the sternocleidomastoid muscle during childbirth.
- Shortening of the muscle usually follows, which causes lateral bending of the head to the affected side



With the exception of some smooth muscle tissue, the muscular system develops from the mesodermal germ layer



Summary

- Skeletal muscle is derived from paraxial mesoderm, which forms somites from the occipital to the sacral regions and somitomeres in the head
 - Smooth muscle differentiates from
 - **somatic mesoderm** which provides smooth muscle in the walls of many blood and lymphatic vessels.
- visceral splanchnic mesoderm surrounding the gut and its derivatives
 - ectoderm muscles of the iris (sphincter and dilator pupillae) and the myoepithelial cells in mammary and sweat glands
 - **Cardiac muscle** is derived from visceral splanchnic mesoderm surrounding the heart tube.



Thank you