ECRONICON OPEN ACCESS

EC PULMONOLOGY AND RESPIRATORY MEDICINE

Mini Review

Engineering the Airways - The Physics of Cartilage

Keval Shah[1] and Alok S Shah[2]*

[1]*Aditya Birla World Academy, India*

[2]*Lung Injury Center, University of Chicago, USA*

***Corresponding Author:** Alok S Shah, Lung Injury Center, University of Chicago, Medical Center, Chicago, USA.

Received: September 06, 2021; **Published:** September 29, 2021

Abstract

Cartilage is an essential part of the respiratory system and understanding the functioning of the cartilage can be beneficial when dealing with cartilage diseases and abnormalities related to the respiratory system [1]. There is also a great need to understand diseases related to the cartilage because it can help with the diagnosis and treatment of the diseases. Further research into this field can help with prevention and cure of diseases related to cartilage. This article contains an outline of cartilage and its function in the respiratory system and describes diseases related to the cartilage in the respiratory system. It also provides future areas that can be researched in relation to the diseases.

Keywords: *Cartilage; Cartilage Diseases*

What is cartilage?

Cartilage is a tough but flexible connective tissue, around 65 - 80% of which is water and the rest is a gel-like substance called the 'matrix' that gives it its form and function [2]. It is normally found in joints between bones, at the ends of ribs, between vertebrae in the spine, in the ears and nose and in the bronchial tubes or airways [2].

Cartilage is made up of specialized cells called chondrocyte, which produce large amounts of the extracellular matrix made up of collagen fibres, proteoglycan, and elastin fibres [2]. There are no blood vessels in cartilage to supply the chondrocyte with nutrients, so nutrients diffuse through the dense connective tissue surrounding the cartilage and into the core of the cartilage [2]. Due to the lack of blood vessels, cartilage grows and repairs more slowly than other tissues [2].

There are 3 main types of cartilage: hyaline, fibrous and elastic cartilage. The respiratory system consists mainly of hyaline cartilage; it is found in the nose, trachea and larynx [2]. It is a low-friction, wear-resistant tissue which is best suited to bear and distribute weight [2]. It is a strong, rubbery, flexible tissue but has a poor regenerative capacity [2].

Functions of cartilage in the respiratory system

Trachea

The trachea is made of cartilaginous rings that allow the windpipe to move and flex while providing support to it [2]. There are commonly sixteen to twenty individual cartilages in the windpipe. Each one is around one to two millimetres thick, with a depth of around four

to five millimetres [2]. The C-shaped structure of the tracheal rings, with soft tissue near the oesophagus, allows the oesophagus to expand when food is swallowed and allows the trachea to expand when breathing while preventing the trachea from collapsing [2].

Larynx

There are 9 cartilages in the larynx: the thyroid cartilage, cricoid cartilage, epiglottis, arytenoid cartilages, corniculate cartilages, and cuneiform cartilages [2]. The thyroid cartilage acts as a shield surrounding the anterior part of the larynx; it is popularly known as the Adam's apple [2]. The cricoid cartilage is known as the cricoid ring or signet ring, and it completely encircles the trachea [2]. The epiglottis acts as a gateway that keeps solids and liquids from entering the lungs; it is a leaf-shaped flap covering the opening of the larynx [2]. The pair of arytenoid cartilages are a pair of small, hard but flexible cartilages that are situated above the posterior section of the cricoid cartilage [2]. These cartilages have two functions: vocal processing and muscular processing [2]. The pair corniculate cartilages, also known as the cartilages of Santorini, are small elastic cone-shaped cartilages that prolong the arytenoid cartilage backward and medialward [2]. The pair of cuneiform cartilages, or Wrisberg cartilages, are elongated fibrous pieces of cartilage that are placed on either side of the aryepiglottic fold and support the vocal folds and part of the epiglottis [2]. These cartilages move with the help of joints between them [2].

Nose

The nasal cartilages provide support and structure to the nose and are made up of mainly hyaline cartilage [2]. There are 6 cartilages in the nose: the greater alar cartilages(nostrils), the lateral nasal cartilage, the accessory cartilages, the cartilage of the septum, the vomeronasal cartilage and the lesser alar cartilages [2]. The greater alar cartilages are more flexible cartilages that allow our nostrils to expand and contract while retaining their structure [2]. The lateral nasal cartilage is located under the nasal bone and is triangular [2]. The accessory cartilages are small cartilages that connect the greater alar and lateral nasal cartilages [2]. The cartilage of the septum, also known as the quadrangular cartilage because of its roughly quadrilateral shape, is between the two nostrils and separates them [2]. It also links the lateral cartilages to the nasal bones [2]. Vomeronasal cartilage, also known as the Jacobson's cartilage, links the nasal septum to the vomer bone (a thin, flat bone between the nostrils) [2]. The lesser alar cartilages are three to four small nasal cartilages connected to the upper jawbone [2].

Elasticity and compressive strength of cartilage

Elasticity is the ability of a material to return to its original shape after being stretched or compressed [3]. Compressive strength is the maximum compressive stress that a given solid material will sustain without fracture [4].

Cartilage is an elastic tissue, so it can return to its original shape after being stretched or compressed. It also has great compressive strength so that it can withstand the forces acting on it. These properties of cartilage are critical for breathing because it allows for some stretching while also maintaining a firm shape, which allows for the airways and lungs to expand while keeping its shape.

Description of disease

Congenital diseases

Williams-Campbell syndrome is a rare congenital disease of the bronchial cartilages characterised by atrophy or absence of the subsegmental bronchial cartilages of the 4th to 6th order bronchial divisions leading to dilation of the distal bronchiole [5]. Williams-Campbell syndrome occurs early in life when the lungs are still developing [6]. There are two schools of thought about the cause of Williams-Campbell syndrome [6]. The congenital hypothesis has not identified the gene yet, but it is thought to be recessive [6]. The acquired hypothesis posits that bronchiectasis is secondary to adenovirus infections that cause bronchomalacia [6].

Pectus Carinatum is a genetic disorder that is generally related to other genetic disorders such as Down syndrome, Edwards syndrome and Marfan syndrome among others [7]. Pectus Carinatum is characterised by a malformed chest wall, causing it to jut out, resembling a bird's chest, giving it the alternative name-pigeon chest. [7].

Acquired diseases

Costochondritis is an inflammation of the cartilage connecting the ribs to the sternum [8]. Costochondritis is sometimes thought to be a heart attack due to the acute pain in the chest [8]. Causes of costochondritis are thought to be related to problems in the back, age, musculoskeletal problems or due to other diseases, but these have been confirmed [8]. Acute pain related to costochondritis can be triggered by exertion of the muscles near the affected region or by pressure applied to the region [8].

Effect of disease

Williams-Campbell syndrome-Maldevelopment of the bronchi leads to recurrent pneumonia and bronchitis-obstructive symptoms such as coughing and wheezing in children [7].

Pectus Carinatum-Children affected by Pectus Carinatum may feel short of breath, have a fast heartbeat, feel tired and have chest pain [8]. Pectus Carinatum may also cause other respiratory infections such as asthma [8].

Costochondritis-Those with costochondritis may not be able to breathe deeply due to acute pain in the chest and may not be able to exercise the affected region [9]. The acute pain mimicking that of a heart attack may also be repetitive for those affected by costochondritis [9].

Treatment

There is no specific treatment for the disease but oral or intravenous antibiotics can be used as a preventive measure [7]. Exercise or inspiratory muscle training can help cases with bronchiectasis without cystic fibrosis [7]. The use of antibiotics and corticosteroids may be helpful as well [7].

Pectus Carinatum can be treated with chest braces worn for 6 months to a year [8]. In some cases, surgery can treat Pectus Carinatum [8]. Physical therapy can also help with Pectus Carinatum [8]. In mild cases, treatment might not be needed as long as there aren't any breathing problems [8].

While there is no proven treatment for costochondritis, rest or frequent physical therapy can help ease the pain and reduce the recurrence of the episodes of acute pain [9]. A few back exercises to loosen the muscles in the back have also been effective against costochondritis [9].

Future Areas of Research/Conclusion

Research can be conducted to identify the gene responsible for Williams-Campbell syndrome so that it can be identified at a much earlier stage and can possibly be cured. Research can be done into materials that can be used to replace the absent cartilage to reduce the risk posed by Williams-Campbell syndrome. Research on the ways to prevent, cure and help with Williams-Campbell syndrome can also be conducted. Research can be conducted on alternative medicine treatments to cure Williams-Campbell syndrome.

Research can be done to find the exact cause of Pectus Carinatum and possibly a way to correct the gene causing it.

Research can be done to find correlations and commonalities between people that have costochondritis to predict the likelihood for a person to be affected by it. Research can be done to look for ways to treat costochondritis and the existing remedies can be studied. Research can also be done into how to identify costochondritis at an early stage and how to differentiate its symptoms from those of a heart attack.

Bibliography

1. Mandal, Ananya, "What is Cartilage?", News-Medical (2019).
2. Healthline Editorial team, "Tracheal Cartilages", Healthline (2018).
3. "Elasticity", OxfordLearner'sDictionary.com, Oxford Learner's Dictionary (2021).
4. "Compressive strength", Merriam-Webster.com Dictionary, Merriam-Webster (2021).
5. Ataya Ali, Eloise Hartman, "Rare and Interesting Cases in Pulmonary Medicine", Science Direct (2017).
6. Aldave Adrian and William Saliski, "The Clinical Manifestations, Diagnosis and Management of Williams-Campbell Syndrome", National Center for Biotechnology Information (2014).
7. Reyes-Ferral Cynthia. "What is Pectus Carinatum?", KidsHealth (2017).
8. Mayo Clinic Staff, "Costochondritis", Mayo Clinic (2020).
9. Mayo Clinic Staff, "Costochondritis", Mayo Clinic (2020).

Volume 10 Issue 10 October 2021