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Review Article

Implications of Age-Related Changes in Anatomy for Geriatric-Focused Difficult Airways

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SUMMARY

The structure and function surrounding the airway change by the age, which may ultimately result in having anatomic features of difficult airways in the elderly. Hence, we reviewed the literature focusing on the age-related anatomic changes and accordingly to compare the characteristics of difficult airways. With age, teeth wear and loss, protein and collagen synthesis reduction, and bone loss and muscle atrophy results in aged face (chin protrusion, cheek retraction and drooping), jaw restriction (temporomadibular joint disc displacement and osteoarthritis), neck and back stiffness, and kyphotic deformities (degeneration of spinal articular cartilage, intervertebral discs, and spinal osteoporosis). These age-related changes in anatomy are compatible with the predictors of a difficult airway. We hope that these age-related anatomic approaches will prospectively allow a detailed understanding of the hallmarks resulting in geriatric-focused difficult airways in the future studies.

1. Background

The elderly population is gradually increasing. The importance of evaluating the difficulty in endotracheal intubations before anesthesia in the elderly has been increasing. Delays in endotracheal intubation can cause fatal consequences due to limited organ reserve and comorbid conditions with aging.[1] Although the evidence is still limited, previous studies have shown the elder patients predisposing to have difficult airway.[2–8] However, the impact of age-related anatomic changes on the occurrence of difficult airway in the elders is not yet clear.[9–14] Hence, this article was driven to review the age-related changes in anatomy, and its relations with the hallmarks of difficult airway in the elderly.

2. Assessment

A focused literature search with consultation from a professional librarian was performed on data from January 1972 to December 2016. References of identified studies were also checked for relevancy. Hand-searches of relevant journals were also performed.

3. Predictors of difficult airways

Many national airway guidelines emphasize the importance of a thorough and skilled assessment of all patients requiring airway management.[15–17] A complete airway evaluation should include predicted ease or difficulty of a tracheal intubation, as well as predicted success of fallback options to achieve oxygenation, and a surgical airway.[17] Experts believe that difficult airways occurring with the following procedures: tracheal intubation, face mask ventilation, supra-glottic placement, and surgical airway access (though it is not limited to these descriptions).[15,16]

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For the patient requiring a tracheal intubation, an airway evaluation is performed primarily to help decide if the intubation can be safely performed after the induction of general anesthesia or if the intubation should proceed with the patient awake.[16] The predictors of difficult direct laryngoscopy consists of a chin protrusion,[5] a limited mouth opening,[5,7,9,11,12,14] limited mandibular protrusion,[18] narrow dental arch,[12] decreased thyromental distance,[7,12] modified Mallampati class 3 or 4,[7,11,14] decreased submandibular compliance,[5] decreased sternomental distance[7,14], limited head and upper neck extension,[7,9,11,14] and increased neck circumference.[5,7,12,19–22]

The predictors of difficult face mask ventilation include having a higher body mass index or weight,[4,8] older age,[4,8] male sex,[3,8] decreased thyromental distance, modified Mallampati class 3 or 4,[3,4,8] beard,[3,4] lack of teeth,[4,8] history of snoring or obstructive sleep apnea,[3,4,8] limited jaw protrusion,[4] history of neck radiation.[3,4,8,23–25]

Accordingly, most the predictors of difficult airways count on the anatomical variation.[3,5,7,12,26] As the number of predictors of difficulty increases, the probability of actually encountering problems rise.[5,22,26] Furthermore, aging changes body structure, so the elderly is prone to structural and functional changes surrounding the airway. A craniofacial growth does not stop in young adulthood, but it is a continuous process even into later ages.[27,28] Degenerative, pathological, or post-treatment changes are accompanied with changes over a person's life. For example, difficult airways may be the result of dental attrition, dental loss, atrophy of alveolar bone, temporo-madibular joint (TMJ) disc displacement and osteoarthritis, and head and neck joint changes.[29,30] Hence, difficult airways are considered in elderly patients.

4. Age-related changes in anatomy and the implication of difficult airways

4.1. Age changes in teeth

Experts believe that teeth are exceptionally useful in determining a person's age.[40] Interproximal attrition, cementum regeneration, in combination with comparing of the amount of dentine formation, the position of the epithelium of attachment, and the size and shape of the pulp cavity to previous produced data from teeth of a known age, teeth are exceptionally useful in determining a person's age.[31]

Changes in the teeth are resulted from incremental effects of wear, disease, and aging. Occlusal wear may be due to attrition (tooth-on-tooth contact), abrasion (tooth-on-food contact, or contact with other foreign bodies), or erosion (acid, aspirin, vitamin C, or gastric juice). Interproximal attrition between the upper and lower teeth may result in the loss of as much as 1 cm from the overall arch circumference by the age of 40.[1]

Cementum deposition persists throughout the life. While the superficial cementum ages, a new layer of cementum is deposited to keep the attachment of intact teeth to the jaw. However, the thickness of apical cementum, which determines the length of the teeth, is approximately tripled between the ages of 10 and 70 years.[32]

The attrition of the molar cusps and cementum regeneration enable the lower jaw to move forward relative to the upper jaw, tending to establish an edge-to-edge occlusion of the incisors and to appear chin protrusion, which is a factor of difficult intubation.[5]

4.2. Age changes in jaw bones and temporomandibular joints

Alveolar bone undergoes atrophy and jaw resorption when several teeth are removed.[1] Dental loss in the lower jaw often results in a thin mandible, and an atrophy of the muscles of mastication.[1] The bulk of the masseter and medial pterygoid muscles significantly reduce with age.[33]

During the post-extraction healing period, the loss in width of the alveolar ridge is greater than the loss in height.[34] The loss of the posterior teeth results in an over-closure of the oral cavity. If all of the teeth are lost, the lower gums and upper gums that cannot come into contact with each others; however, this ultimately becomes possible due to the stretching of the ligaments and capsules of the TMJs.[35]

The prevalence of disc displacement and osteoarthritis of the TMJ increases with age.[36] Osteoarthritis of the TMJ is characterized by an erosion and flattening of the condylar surface, perhaps leading to a locked jaw.[37] Although most patients with TMJ disorders experienced mild distress, the erosion and flattening of the condylar surface restricts the function of the jaw in the elderly.[38–40] In addition to the changes of the condyles by age, the evaluated predictors of difficulties are regarded to the number of teeth lost on either side, but not associated to the degree of ocular attrition or cusp surface change.[35]

The age-related disc displacement and osteoarthritis of the TMJ limits mouth opening, which is one factor of difficult intubation.[5,7,9,11,12,14,22] The mandible resorption and alveolar remodeling diminishes the jaw and causes a concave appearance in the check retraction and drooping,[41] which is a typical appearance of an aged face, and also a predictor of difficult mask ventilation (in our preliminary data).

4.3. Age changes in the oral mucosa

With age, the oral mucosa becomes thin, smooth and dry with a loss of elasticity and stippling.[42,43] These changes are probably the result of changes in the epithelia and dermis.[44,45] The decrease in proliferative activity of the fibroblasts, proteoglycan synthesis, protein and collagen synthesis, the change in clonal heterogeneity in fibroblast phenotypes, and a thickening of collagen and elastin fibers may reduce the flexibility and resilience of the oral cavity with age.[46] The age-related changes of the oral mucosa may limit the mouth opening, and results in difficult intubation.[5,7,9,11,12,14,22]

4.4. Age changes in bones and joints

Bone loss in the elderly is largely the result of excess osteoclast activity, possibly resulting from a decline in estrogen, dietary vitamin D deficiency, age-related reductions in the efficiency of 1-α hydroxylation of vitamin D, and insufficiency of sunlight exposure.[47–49] Spinal osteoporosis causes progressive height losses and kyphotic deformities in the elderly.

The functions of mammalian synovial joints mostly depend on the properties of the articular cartilages, which cushion the subchondral bone and provide a low-friction surface that is necessarily for free movement. With age, articular cartilage thins because of decreases in water content, depletion of cartilage proteoglycan, and chondrocyte apoptosis.[50–53] The cartilage surface starts to break down and reduces its ability to maintain and repair itself. Thus, these contribute to age-related degeneration and the development of osteoarthritis.

The tensile strength of tendons and ligaments-bone complexes also declines with age, probably resulting from a reduced synthesis and post-translational modification of collagen.[54] Neck and back stiffness are common in the elderly, and are likely due to age-related changes of intervertebral discs. The diameter of the nucleus pulposus reduces with age, and the hydrostatic pressure increases within the annulus, which compresses the discs more and narrows the intervertebral space. These factors decrease the height