www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(12): 786-796

www.thepharmajournal.com
Received: 03-09-2022
Accepted: 05-10-2022

Hemali A Patel
M.V.Sc. Department of Veterinary Medicine, Kamdhenu University, Anand, Gujarat, India

Shima Saiyad
M.V.Sc. Department of Veterinary Microbiology, Kamdhenu University, Anand, Gujarat, India

Neha Rao
Assistant Professor, Department of VCC, Kamdhenu University, Anand, Gujarat, India

Corresponding Author:
Hemali A Patel
M.V.Sc. Department of Veterinary Medicine, Kamdhenu University, Anand, Gujarat, India

Common health issues related to brachycephalic dogs

Hemali A Patel, Shima Saiyad and Neha Rao

Abstract
Ocular problems in brachycephalic are associated with shallow orbit, prominent anterior positioned globe, excessive corneal exposure, a large palpebral fissure, entropion production and excessive nasal fold Brachycephalic dogs are having small size of mouth have to fit all 42 teeth and longer lower jaw compare to upper jaw leads to dental malocclusion like overcrowding, under erupted teeth, tartar, palatitis, gingivitis, etc. Compressed occipital and temporal bones leads to hypoplasia of the tympanic bullae predispose brachycephalic dogs to auditory tube dysfunction, fluid accumulation in the middle ear and reduced hearing.
Gastrointestinal (GI) disorders in brachycephalic dogs, including hiatal hernia, pyloric mucosal hyperplasia, pyloric stenosis, esophageal deviation, esophagitis and gastro-esophageal reflux, as well as gastritis and duodenitis. A corkscrew tail is the heritable leads to instability of spine and increased potential for compression of nerves or the spinal cord leading to pain, ataxia and loss of hind leg function and skin fold dermatitis (Intertrigo).
Dermatological disorders including facial and tail fold intertrigo, pattern baldness, atopic dermatitis, demodicosis, Malassezia dermatitis, mast cell tumors, muzzle, pedal folliculitis and furunculosis are commonly encountered in brachycephalic dog. Dystocia are common in some extremely brachycephalic breeds due to the size of the puppies being born compared with the size of the mother's pelvis. Upper airway obstruction is common in brachycephalic dogs so they have to work harder to breathe leads to reduced their thermoregulation ability.
The group of respiratory problems widely recognized in brachycephalic dogs as Brachycephalic Obstructive Airway Syndrome (BOAS) or Brachycephalic Syndrome caused by stenotic nares, excess long soft palate, everted laryngeal saccules, hypoplastic leads to breathing difficulty. Special anaesthetic consideration are required for brachycephalic dogs due to airway abnormalities. Rapid induction and recovery are essential. Inhalant anaesthetics are safest for brachycephalic dogs. Recovery should be in sternal recumbency with uplifted head.

Keywords: Brachycephalic, health issues, BOAS, Anaesthetic consideration

1. Introduction
The domestic dog has evolved from wolves (progenitor dog) around 18,000 to 32,000 years ago and has undergone human selection for breed specific traits and appearances. An animal's conformation-their overall structure and appearance-is highly varied between domestic dog breeds. Certain conformations are increasingly popular because of their appearance but may involve anatomical changes which are harmful. Exaggerated conformational characteristics and the associated genetic variants are causing increasing health problems (Marsden *et al.*, 2016) [13].
Canine and human co-evolution have disclosed remarkable morphological plasticity in dogs. Brachycephalic dog breeds are increasing in popularity, despite them suffering from well documented conformation-related health problems. This has implications for the veterinary caseloads of the future. Whether the recent selection of dogs with progressively shorter and wider skulls has reached physiological limits is controversial. The health problems and short life expectancies of dogs with extremely short skulls suggests that we may have even exceeded these limits (Fawcett *et al*., 2018) [7].
Small brachycephalic breeds are becoming more and more popular with the pet-owning public. Such dogs are often described as being very cute, friendly and playful, but many other breeds also display these characteristics, so compared to other breeds, the most distinguishing characteristics are that brachycephalics have some childlike features, with relatively small, round faces and prominent, frontally positioned eyes, which many owners find attractive (Sanchez *et al.*, 2017) [24]. Due to craniofacial confirmation of brachycephalic breed enabling increased biting forces and increased their appeal as "lap dogs" or for a companion role (Packer *et al*., 2015) [18].

1.1 The term Brachycephalic means?

Appearance was found to be the most common reason, with their baby-like features often being attractive. It was also found that owners of brachycephalic dogs were more likely to live in apartments, and therefore the small size of the breeds was said to be a factor. Owners of these breeds are also younger and the authors suggest that the media may have been influential with brachycephalic breeds being used more frequently in advertising (Packer *et al.*, 2017).

Brachycephalic term derived from Greek word Brachy means "short" and cephalic means "head". Brachycephalic is a discrete skeletal mutation.

1. Flattened muzzle or muzzle squashed inwards.
2. Short heads.
3. Shallow eye socket.
4. Lower jaw is disproportionately longer than upper jaw.

Through selective breeding the skeletal muzzle length has been reduced but the size of the soft tissue in the skull is not proportionally reduced, resulting in compression of the nasal cavity, partial obstruction of the pharynx and larynx and in some cases compression of the brain and base of the spinal cord (Pollinger *et al.*, 2005) [22].

2. List of brachycephalic dog breeds

1. Affenpinscher (Germany)
2. American Staffordshire terrier (America)
3. American Bulldog (America)
4. Boston terrier (America)
5. Boxer (Germany)
6. Brussels griffon (Belgium)
7. English Bulldog (England)
8. Cane Corso (Italy)
9. Chihuahua (Mexico)
10. Chow Chow (China)
11. Dogo Argentino (Argentina)
12. French Bulldog (France)
13. Dogue de Bordeaux (France)
14. English Mastiff (England)
15. French Bulldog (France)
16. Japanese Chin(China)
17. King Charles spaniel(England)
18. Neapolitan mastiff(Italy)
19. Newfoundland (Canada)
20. Pekingese (China)
21. Pug (China)
22. Presa Canario (Spain)
23. Tibetan Special (Tibet)
24. Shar Pei (China)

(Marsden *et al.*, 2016) [13]

3. Types of dog based on skull shape

Dogs are probably the world's most morphologically diverse mammalian species, not least as far as the shape of the skulls is concerned. The shape of the head, or more accurately the skull of dogs can be categorized as one of three basic types: brachycephalic, mesocephalic and dolichocephalic. The overall body size of the dog does not determine the shape of the head and the skull (Ekenstedt *et al.*, 2020) [6].

Dogs of any size can have one of these three basic head types:

1. **Brachycephalic (Short faced):** Breeds are the shorter nosed, flat faced breeds whose skulls are broad. *i.e.*, Pugs, Boston Terriers, Boxers, Bulldogs, and Pekingese
2. **Dolichocephalic (Long faced):** Breeds are those with extremely long skulls. Their noses are long and slender. *i.e.*, Greyhounds, Collies, Setters, Dachshunds, Italian Greyhounds and Great Danes.
3. Mesocephalic dog breeds possess skulls of intermediate length and width. *i.e.*, Beagles, Golden Retrievers, Labrador Retrievers, German Shepherds and Pomeranians. (Ekenstedt *et al.*, 2020) [6]

4. Confirmation of brachycephalic dogs

The conformation of all dogs was measured using established breed-defining measurement protocols. Thirteen conformational features shown to be breed-defining were measured (All measurements were made to the nearest millimeter):

i)	Muzzle length	vi)	Neck girth	xi)	Height at the base of tail,
ii)	Cranial length	vii)	Chest girth	xii)	Fore limb circumference
iii)	Head width	viii)	Chest width	xiii)	Hind limb circumference
iv)	Eye width	ix)	Body length		
v)	Neck length	x)	Height at the wither		

- **Muzzle length:** The distance (mm) from the dorsal tip of the nasal planum (C) to just between the eyes where the inside corners of the eyes meet (B) (as the stop is not discernible on longer-muzzled dogs with a less pronounced facial angle) (Packer *et al.*, 2012) [19].
- **Cranial length (CL):** The distance (mm) from the stop to the occipital protuberance (A), following the curve of the cranial surface (rather than a linear measure), and was measured from just between the eyes up the face, between the ears, to the back of the head where the bony process projects out (B) (Packer *et al.*, 2012) [19].

Fig 1: i) cranial length (A-B) and ii) muzzle length (B-C)

The degree of brachycephaly (facial foreshortening) was quantified by the

$$\text{Craniofacial ratio (CFR):} \frac{\text{The muzzle length}}{\text{The cranial length}}$$

(Packer *et al.*, 2012) [19]

This is demonstrated in (left-right) an extremely brachycephalic Pug (CFR = 0.08), a moderately brachycephalic Bulldog cross (CFR = 0.23) and a mildly brachycephalic Boxer (CFR = 0.35 (Packer *et al.*, 2015) [18].

5. Morphology of skull and muzzle of brachycephalic

A dog's skull is anatomically shaped by the cranial vault (superior), the skull base (inferior) and the facial skeleton. The cranial vault comprises various bony parts, connected by skull sutures. The various skull bones in young animals are still open (fontanelle) to ease their passage through the birth canal. The muzzle is where the respiratory tract begins. The muzzle is connected to the throat, the inner ear and what are

known as sinus cavities, cavities filled with air and coated with mucous membranes in the facial skeleton bone. The channel through which tears flow from the eyes (lacrimal pathway) also ends in the nose (Schoenebeck *et al.*, 2013) [26].

The appearance of brachycephalic dogs is characterised by a short, convex skull shape with a marked fold (stop) between the cranium and the nasal bridge. As a dog's skull develops, there are four bony plates which meet in the upper middle of the head and are the last bony structures to fuse or ossify. Skull sutures usually close about 4-5 weeks after birth. There are cases where the opening is fairly slow to close and the process is not completed until the dog is six months old. In extreme cases the fontanelle remains open (Noeller *et al*., 2006) [17].

An open fontanelle is related to the development of water in the brain, or hydrocephalus ("hydro" (water) and "cephalus" (head). Water in the brain occurs when the drainage system in the skull does not work properly, obstructing the absorption and elimination of cerebrospinal fluid from the brain and causing a build-up (Noeller *et al*., 2006) [17].

The increased intracranial pressure means that the frontal and parietal bones do not close. An open fontanelle can occur in any breed of dog, but the condition is most commonly found in small, brachycephalic dog breeds such as the Maltese, Chihuahua, Boston terrier and Pomeranian. An open fontanelle not only leaves the brain vulnerable to injury, but can also result in neurological abnormalities should water in the brain occur. Since the condition can be hereditary, a dog with an open fontanelle should not be used for breeding (Noeller *et al*., 2006) [17].

Brachycephalic dogs suffer from an open fontanelle and Chiari (small head size) like malformation-Syringomyelia (A small head size (Chiari malformation) in relation to the brain can cause the brain to protrude into the base of the spinal cord, leading to cysts, overcrowding cranial fossa), other hereditary skeletal conditions such as patella luxation, corkscrew tails and congenital malformations of vertebrae associated with neurological deficiencies (Schoenebeck *et al.*, 2013) [26].

Frontal sinuses and nasal conchae show a marked postnatal development but in brachycephalic animals shape and size of frontal sinuses and nasal conchae differ considerably from normocephalic skulls. In the French bulldog the frontal sinuses are extremely small and in the Pug they are missing completely.

Highly shortened facial bones and the resulting dislocation of nasal structures caused by the dorsorotation of the teeth. Profound and severe brachycephaly is characterized by a dorsal rotated upper and lower jaw and an abnormal dislocation of conchae with a steep course of intranasal airways and the nasolacrimal drainage system. Severe stages of brachycephalic show a horizontally positioned and dorsally rotated canine tooth. As a consequence of the hypogenesis of the upper jaw we suspect an aberrant growth of conchae. Impeded in their normal development by a lack of space they grow into free gaps of adjoining structures (Noeller *et al.*, 2006) [17].

Table 1: Diseases that is associated with brachycephalic breed

Airways		Ears	Gastro- intestinal	Eyes
Nose	Stenotic nares	Narrowed ear canals	Pyloric stenosis	Corneal ulcerative disease
	Increased mucosal contact points	Thickened tympanic bulla walls	Hiatal hernia	Trichiasis Lagophthalmos
	Aberrant turbinates	Rostral location of bulla	Gastro-esophageal reflux	Pigmentary keratitis
	(Naso) pharyngeal narrowing and collapse	Auditory tube dysfunction	Esophagitis Gastritis Duodenitis	Luxation of eye ball
Pharynx	Overlong soft palate	Middle ear effusion	Mucosal hyperplasia	
	Laryngeal narrowing			
Larynx	Laryngeal collapse			
	Tracheal hypoplasia			
Trachea & Bronchi	Tracheal and bronchial collapse			

(Ryan *et al.*, 2017) [23]

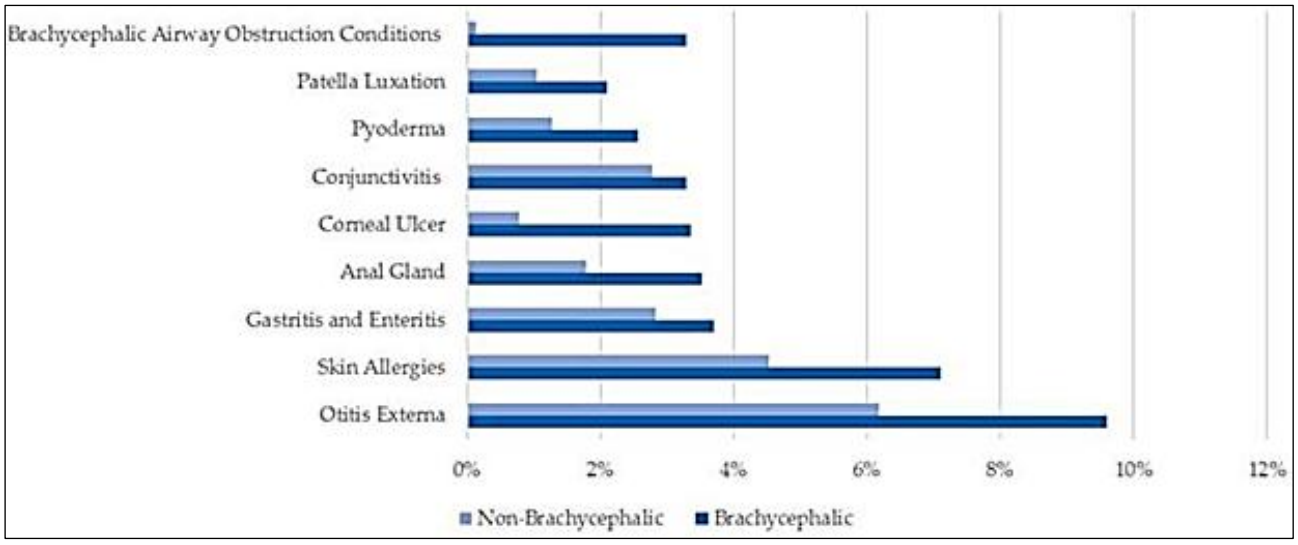

Fig 2: Prevalence of insurance claims for various disease (Feng *et al*., 2018) [8]

6. Brachycephalic ocular syndrome (BOS)

6.1 Brachycephalic Ocular Syndrome (BOS)

Eye problems associated with conformation in brachycephalic breeds (Van Der Woerdt, 2004) [30]. Ocular problems in brachycephalic dogs are associated with:

i) Shallow orbit.
ii) Prominent anterior positioned globe.
iii) Excessive corneal exposure.
iv) Large palpebral fissure.
v) Excessive nasal fold.

(O'Neill *et al*., 2017)

6.2 Corneal ulcer

Corneal ulcer is characterized by superficial or deep erosive processes in the cornea with loss of epithelium and stroma.

Table 2: Several conformational traits that increase the risk of corneal ulceration in brachycephalic animals

Conformational traits	Risk factors
Shortened muzzle	Results in shallow orbits and leads to protrusion of the eyes.
Euryblepharon	Reduces animal's blinking ability over the corneal surface. Poor tear film distribution and desiccation of the axial cornea.
Macroblepharon	Increase corneal exposure leads to trauma.
Excessive nasal fold	Hair from nasal fold irritate cornea and develop ulcer.
Sub-optimal tear production	Large, exposed globes increase the rate of tears evaporate.
Entropion	Cause trichiasis leads to irritation which contributes to ulcer formation.
Poor corneal sensation & low corneal nerve fiber density	Reduced signs of ocular pain compared to a non-brachycephalic animal.

(Marshall, 2020) [14]

Diagnosis: Visual examination.
Fluorescein dye test.

Medical therapy: Topical antibiotics (Tobramycin, Moxifloxacin, Ofloxacin Gentamicin), Platelet rich plasma.
Non-steroidal anti-inflammatory drugs (*Flurbiprofen sodium*).
Five percent atropine to prevent ciliary spasm.
Ocular lubricants (polyacrylic acid or hyaluronic acid).

- Use of an Elizabethan collar.

(Sanchez, 2017) [24]

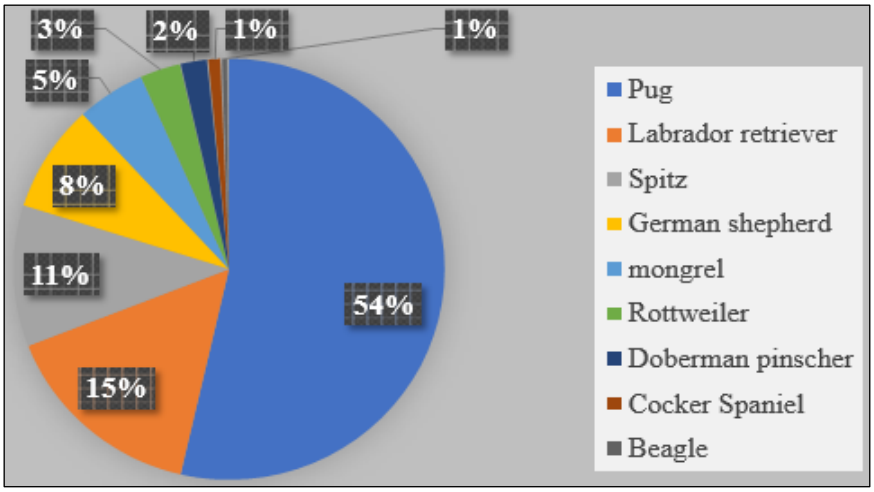

Fig 3: Incidence of corneal affection in canine at Department of Veterinary Surgery & Radiology, Anand, 2015-2017 (Kelawala *et al*., 2017) [11]

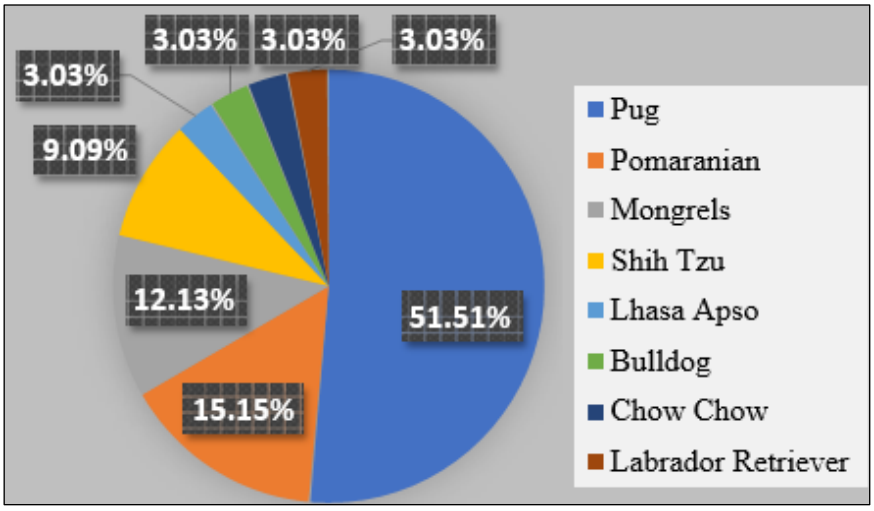

Fig 4: Incidence of corneal ulcer in canine at Department of Veterinary Surgery & Radiology, Anand, 2020 (Patel *et al*., 2020) [20]

6.3 Pigmentary keratitis
It is a gradual progression of corneal pigmentation that has been reported in a large proportion of Pugs. The pigment extends from the medial to central cornea and can lead to blindness in advanced cases. The exact etiology remains unknown, but inflammation is thought to play a role in the disease process. Dry eye can lead to pigment proliferation, but it is not a pre-requisite. Common in Pug. It can be treated with 0.05% cyclosporine mix with edible oil every 15 days for life long use (Labelle *et al.*, 2013) [12].

6.4 Exophthalmos: Abnormal protrusion of the eyes owing to a shallow orbit (Stades *et al.*, 2007) [27].

6.5 An oversized palpebral fissure: An excessively wide eyelid aperture relative to the size of the eyeball (Stades *et al.*, 2007) [27].

6.6 Distichiasis: Hairs similar to eyelashes which are abnormally positioned (*i.e.*, on the free margin of the eyelid) and can therefore rub against the cornea (Fritsche *et al.*, 1996) [9].

6.7 Epiphora
Tear overflow (which can result in skin irritation in the nasal fold). The underdeveloped muzzle is out of proportion with the normally developed scalp, resulting in deep nasal folds. In addition to the nasal fold trichiasis risk, the animals are also at high risk of developing dermatitis, inflammation of the skin in the nasal fold caused by rubbing and microbial overgrowth (bacteria and yeast), promoted by the elevated humidity and build-up of secretions in this environment. S kin fold dermatitis gives rise to an unpleasant odour and causes the dog discomfort; in some cases it can trigger self-injury through rubbing and/or scratching. Daily cleaning of the folds is widely recommended as standard care for dogs of this type, but is often not enough to manage the problem. French Bulldogs have a nasal fold on the dorsal surface of the muzzle, which is so close the tip of the nose that it is completely impossible to clean this deep fold (Fritsche *et al.*, 1996) [9].

6.7 Lagophthalmos: Inability to close the eyelids completely. Protruding eyes leads to ineffective blinking which leads to drying of the eyes accompanied by loss of corneal sensation (Christiane *et al*., 2008) [3].

6.8 Luxation of the eyeball from the orbit: Eyeball is located in shallow orbit and eyelid aperture is so wide so eyeball can easily pop out from the orbit (Stades *et al.*, 2007) [27].

7. Dental/Oral problems
Commonly seen when the skin of the head or neck is pulled or when the dog becomes excited. It is painful condition (Fritsche *et al*., 1996) [9].

In brachycephalic dog breeds maxilla is too short compared to the mandibles. Like all dogs it has 42 teeth but have a very little space to fit them in, as a result teeth will be overcrowded and grow in odd angles that trapped food debris easily. Maxillary premolars are so crowded, there is no gingiva between and little or no alveolar bone support. Upper incisors are in traumatic contact with the floor of the mouth which cause injury. Some teeth are under erupted due to crowding and impacted against opposing teeth. The result is that the animal effectively bites itself every time it closes its mouth (Hale, 2013) [10].

The traumatic contact between the maxillary incisors and the mandibular structures will often lead to traumatic pulpitis and pulp necrosis in the maxillary incisors. Severe bunching-up of the palatal rugae with entrapment of hair, food and bacteria leading to chronic, painful palatitis with small mouth, brachycephalic dogs often have overlapping teeth or baby teeth that do not fall out. Tartar tends to build up quickly leads to gingivitis and other mouth disorders. Brachycephalic dogs suffer from dental malocclusion leads to difficulty in chewing their food. A soft food or wet food and sweet potatoes given to them. Annual dental examination and teeth cleaning when needed are essential to maintaining good oral health (Hale, 2013) [10].

Some of the dental/oral abnormalities associated with brachycephalic can be mitigated by selective extraction, but many animals do not get to benefit from these procedures and live with chronic dental pain and infection (Hale, 2013) [10].

8. Ear problems
The occipital and temporal bones are more compressed as well, which has led to hypoplasia of the tympanic bullae and abnormal function of the Eustachian tube. The horizontal ear canals of these breeds are known to be very narrow and chronic otitis externa is commonly encountered and can rapidly result in complete obliteration of the lumen of the canals with hyperplastic tissue. Ear surgery is challenging, even in dolichocephalic dog breeds, but can be very complicated in brachycephalic breeds because of these factors mentioned. Indications for total ear canal ablation and lateral bulla osteotomy (TECA/LBO) in brachycephalics are usually proliferative otitis externa, chronic otitis media, or ear canal neoplasia (Venker-Van Haagen, 2005) [31].

Brachycephaly leads to changes in the ear canals and tympanic bullae which appear to predispose brachycephalic dogs to auditory tube dysfunction, fluid accumulation in the middle ear and reduced hearing. Brachycephalic dogs have much narrower ear canals especially in the horizontal section leads to chronic otitis externa based on allergic (Schlensker *et al*., 2015) [25].

Skin disease in these animals quickly progresses from mild ceruminous otitis externa to excessive hyperplasia of the skin and ceruminous glands. This can subsequently lead to severe stenosis of the ear canals. Inflammatory polyps arising from the skin lining the ear canal appear to be more commonly seen in brachycephalic dogs. Many dogs with this form of otitis externa seem to develop the triad of otitis externa, media and interna in a relatively short timespan and will be candidates for total ear canal ablation with lateral bulla osteotomy. This is a difficult and challenging procedure in these breeds due to the abnormal middle ear anatomy and extensive calcification of the ear canals secondary to the disease (Schlensker *et al.*, 2015) [25].

A significantly thicker tympanic bulla wall and smaller middle ear volume in brachycephalic dogs compared to non-brachycephalic breeds. Brachycephalic dogs are also predisposed to fluid accumulation in the middle ear due to subclinical middle ear infection related to otitis externa, or by drainage problems that result from abnormal tympanic bulla morphology and/or auditory tube dysfunction. It is likely that impaired ventilation of the middle ear predisposes brachycephalic patients to infections, which are thought to ascend from the respiratory tract. Topical and systemic antibiotics are advised for animals with infectious otitis externa and media, but total ear canal ablation with lateral bulla osteotomy is recommended for recurrent cases and those

who present with the triad of otitis externa, media and interna (Schlensker *et al.*, 2015) [25].

In this breed, auditory tube dysfunction is presumed to lead to middle ear effusion with bulging of the pars flaccida of the tympanic membrane, leading to depression, head shaking, ear scratching and reduced hearing. Most brachycephalic dogs will present with signs of inflammation of the externa, middle or inner ear, hearing loss or deafness. Animals presenting with peripheral vestibular ataxia probably also have cochlear dysfunction with decreased hearing. The use of topical ear ointment for the treatment of chronic ear infections can also lead to sensorineural hearing loss. Although total ear canal ablation with lateral bulla osteotomy can further decrease hearing capacity, surgery is indicated to remove the source of inflammation and pain associated with chronic otitis externa and media (Mielke *et al.*, 2017) [15].

9. A corkscrew tail

A corkscrew shaped tail leads to abnormally shaped bones in the spine (hemivertebrae) and is often recognized in brachycephalic breeds, particularly the French bulldog. This is because the breed standard has a coiled tail which requires selecting for hemivertebrae in the tail, predisposing the animal to having hemivertebrae elsewhere in the spine. This condition leads to instability of the spine and increased potential for compression of nerves or the spinal cord leading to pain (which can be severe), ataxia (wobbliness), loss of hind leg function and incontinence. Cork screw tail form tail pocket which predispose to tail fold dermatitis (intertrigo). Uncomfortable when trying to sit and constantly changes the position. Excessive tail licking and rubbing of the perineum. Cleaning of the tail pocket if infection is present and in extreme cases caudectomy is done (Schlensker *et al.*, 2015) [25].

Attempts to lift the tail during examination may cause severe pain, due to its immobility so approached gently and carefully. Hemivertebrae can be identified on radiograph, thus animals intended for breeding should be radiographed and only used if they are not likely to pass on this deformity to their offspring (Schlensker *et al.*, 2015) [25].

10. Gastrointestinal problems

Gastrointestinal (GI) clinical signs in brachycephalic dogs, including hiatal hernia, pyloric mucosal hyperplasia, pyloric stenosis, esophageal deviation, esophagitis and gastro-esophageal reflux, as well as gastritis and duodenitis. These are usually associated with the Brachycephalic Obstructive Airway Syndrome (BOAS) and BOAS is treated the GI signs repealed (Peeters *et al*., 1991) [21].

11. Dystocia

Many brachycephalic dog breeds have major difficulty giving birth. British bulldogs, French bulldogs and Pugs are deliberately selected for a large head, broad shoulders and narrow pelvis, which means the pup's head and shoulders are too large to fit through their mother's pelvic canal, causing major birthing problems. In addition, the mother can have trouble breathing due to the stress and physical exertion of birthing (Universities Federation for Animal Welfare, 2011) [29].

Birthing difficulties (dystocia) are common in some extremely brachycephalic breeds due to the size of the puppies being born compared with the size of the mother's pelvis. Physical features, such as larger heads, result in puppies with heads too large to pass through the relatively narrow pelvises of the bitch without medical or surgical intervention (Wang *et al.*, 2018) [32].

Veterinary assistance is often required for the mother and puppies to safely survive the birthing process. Generally, they can't give birth normally and require veterinary assistance and a caesarean section. A caesarean section is a major surgery which involves anaesthetising the mother, opening the abdomen, and exposing and opening the uterus (womb) to deliver the puppies (Universities Federation for Animal Welfare, 2011) [29].

12. Dermatological disorders

Skin fold dermatitis Skin Fold Dermatitis is the irritation of the skin between folds commonly found on the faces of brachycephalic breeds, as the amount of skin which covers the shortened muzzle is not proportionally reduced as skull length decreases (Becskei *et al.*, 2018) [1].

Most common organisms present in skin fold: *Staphylococcus*, *Streptococcus*, *Pseudomonas* and *Malassezia* species. Commonly found on face and tail. Daily cleaning of the folds. Nasal fold in French Bulldogs is too deep and close to tip of muzzle which is impossible to clean. Topical therapy and surgical resection of folds for facial and tail fold intertrigo (Becskei *et al.*, 2018) [1].

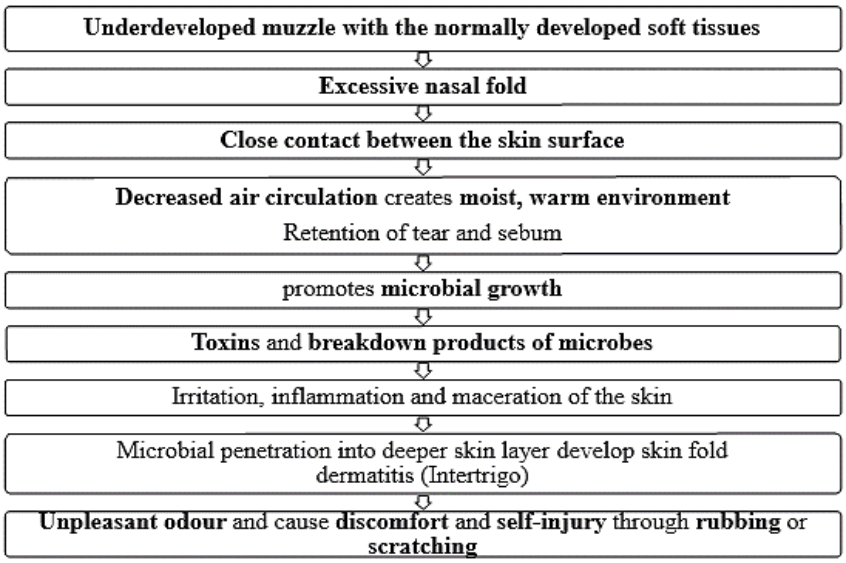

Table 3: Skin conditions and treatment

Skin fold condition	Treatment
Severe bacterial overgrowth with cocci.	Topical antibiotic ointment (mupirocin) BID after cleaning with wipes.
Severe skin fold dermatitis with mixed bacterial overgrowth (cocci and rod-shaped bacteria).	Topical silver sulfadiazine.
Severe skin fold dermatitis with deep pyoderma.	Topical + Broad spectrum systemic antibiotics.
Removal of the surface organism and debris in intertrigo.	Topical products like chlorhexidine and antifungal (miconazole, ketoconazole) mometasone furoate agents are used on intertriginous areas BID.

(Becskei *et al.*, 2018) [1]

Atopic dermatitis, demodicosis, Malassezia dermatitis, tumors, folliculitis and furunculosis are other dermatological disorders encounter in brachycephalic dogs. Dermatological diseases require long-term management. Allergen-specific immunotherapy (systemically and topical) for atopic dermatitis. Surgical resection of pedal furuncles of the paws (interdigital cysts). Parasiticides for demodicosis (Becskei *et al.*, 2018) [1].

13. Thermoregulation

For dogs, panting is an important component of heat dissipation. Patients with brachycephaly have greater respiratory resistance to airflow and a reduced ability to thermoregulate. Heat stress and upper airway obstruction are intrinsically linked. Because of upper airway obstruction, brachycephalic patients must work harder to breathe (Davis *et al.*, 2017) [4].

Upper airway obstruction is common in patients with brachycephaly. The precipitating causes include intrinsic end-stage airway collapse and swelling of the airways caused by panting or tachypnoea or following sedation or anaesthetic, when the airway musculature is relaxed. When their respiratory drive increases due to hyperthermia, anxiety, pulmonary disease or other causes, excessive negative pressures need to be generated to move larger volumes of air. As a consequence, the soft tissues of the upper airway swell, further compromising airflow and heat dissipation. A heat stress can lead to upper airway obstruction, and vice versa (Davis *et al.*, 2017) [4].

Thermoregulation For patients without complete airway obstruction, conservative management can be first attempted. However, patients should not be left unsupervised until they are stable, as intubation can become necessary at any time. Conservative management revolves around three principles:

Oxygen supplementation

- Sedation.
- If the patient is hyperthermic, active cooling.

It is imperative that these patients are managed with as little stress as possible, because struggling increases oxygen demand, and this can precipitate respiratory arrest. Oxygen can be provided via flow-by, mask (although this can be stressful), oxygen hood or oxygen cage. Sedation can be administered intramuscularly and an IV catheter placed when the patient is more stable. Some patients will tolerate a IV catheter placement immediately. Butorphanol (0.2-0.3 mg/kg IV ± medetomidine 5 mcg/kg IV) is a reliable protocol. The goal of sedation is to reduce anxiety and slow the respiratory rate, which will reduce turbulence and improve airflow (Tseng *et al.*, 2004) [28].

The patient should remain conscious and retain a gag reflex. If the gag reflex is lost, the patient must be intubated to protect the airways from aspiration, which can lead to pneumonia. A dose of corticosteroids (dexamethasone 0.15 mg/kg IV or IM) can be administered to help reduce airway swelling. Corticosteroids should not be given to patients during heat stress, due to potential gastrointestinal tract (GIT) complications such as GIT ulceration (Tseng *et al.*, 2004) [28].

All patients should have their rectal temperature taken as soon as is reasonable. Those with temperature greater than 39.5 ◦C should receive active cooling as follows:

a) Administer room temperature IV fluid.
b) Wet the hair-coat with room temperature tap water or wet towels.
c) Place a fan in front of the patient.
d) The rectal temperature should be checked every 10 mins.
e) Active cooling should be stopped once the temperature reaches 39.4 ◦C to prevent rebound hypothermia (Tseng *et al.*, 2004) [28].
f) Patients with heat stress should also be screened for organ injury. The GIT is the most sensitive to damage, manifesting as vomiting, diarrhoea (often haemorrhagic) and ileus. This can be a major source of fluid loss. Other potential complications include acute kidney injury, coagulopathy and hypoglycaemia (Bruchim *et al.*, 2006) [2].
g) Altered mentation is also common, but it is typically quick to resolve (Bruchim *et al.*, 2006) [2].

14. Brachycephalic Obstructive Airway Syndrome (BOAS)

The group of respiratory problems widely recognized in brachycephalic dogs is known as Brachycephalic Obstructive Airway Syndrome (BOAS). The breeding causes excess soft tissue in rh upper airways and obstruct the airways. The narrow airways in these breeds increase airway resistance and inspiratory effort, which eventually lead to dyspnea with an obstructive breathing pattern, stridor and stertor. Decreased exercise tolerance, panting, hyperthermia, cyanosis and collapse are some of the more severe clinical signs. Coughing, gagging, retching, regurgitation and vomiting are also frequently present and indicate secondary or concurrent lower airway or gastrointestinal (GI) disease (Packer *et al.*, 2015) [18].

14.1 Etiology

I. **Stenotic nares:** Dogs with stenotic nares have abnormally narrowed or small nostrils which restricts the amount of air that can flow into the nostrils.
II. Nasopharyngeal turbinates are ridges of bone covered by tissue that help humidify and warm air that is inhaled. When these extend past the nose into the pharynx (the area behind the nose and mouth), they cause variable amounts of airflow obstruction.
III. A dog with an elongated soft palate (the soft part of the roof of the mouth) has a soft palate that is too long for the length of the mouth; the excess length partially blocks the entrance to the trachea (windpipe) at the back of the throat (Packer *et al*., 2015) [18].
IV. Laryngeal collapse is caused by the chronic stress placed on the cartilage of the larynx by other features of

brachycephalic syndrome. Eventually, the larynx (voicebox) is not able to open as wide as normal causing further restriction in airflow. The laryngeal saccules are small sacs or pouches that are located just inside the larynx; these saccules evert (turn outwards) or are sucked into the airway by pressure associated with the increased respiratory effort caused by the stenotic nares and/or the elongated soft palate. Everted laryngeal saccules will further obstruct airway flow (Packer *et al*., 2015) [18].

V. A hypoplastic trachea means that the trachea has a smaller diameter than normal. Tracheal diameter to tracheal inlet ratio (TD: TI) <0.16 seen on a lateral radiograph. Restrict the air flow and increase the respiratory efforts (Packer *et al*., 2015) [18].

14.2 Symptoms

The typical symptoms of BOAS are breathing difficulties. Any of respiratory disease present can cause greater airway resistance, increasing the effort required to inhale. Generally, the more disorders present, the more severe the symptoms (Packer *et al*., 2015) [18].

Symptoms of mildly affected dog

- Noisy breathing especially when inhaling.
- Mouth breathing.
- Frequent panting.
- Snorting when excited.
- Snoring when relaxed or asleep.
- Preferring to sleep on the back.
- Disrupted sleep.
- Trilling easily with exercise.

(Packer *et al.*, 2015) [18]

In addition to the above, symptoms of more severely affected animals may include

- More pronounced airway noise
- Rapid breathing
- Constant panting
- Exercise and heat tolerance
- Hypersalivation
- Abnormally high body temperature
- Collapsing after over activity, excitement, excessive heat and humidity
- Coughing
- Gagging, regurgitating or ratching while swallowing
- Vomiting
- Cyanosis
- Dysphagia
- Abnormal posture
- Assessing sleeping habits (sleep apnoea, choking, sleeping sitting upright) and exercise intolerance can be effective in evaluating BAS and the urgency of surgical intervention.

(Packer *et al.*, 2015) [18]

Factors increase the severity of symptoms

- Obesity
- Allergies
- Over-excitement
- Exercise
- Warm, Humid weather

(Packer *et al*., 2015) [18]

14.3 Diagnosis

Initial veterinary evaluation involves taking a history of clinical signs, along with an assessment of the degree of respiratory compromise. Close questioning of the owners regarding their dog's behavior, respiratory noise, and appearance during different activities (e.g., while on a walk, playing, eating, or sleeping) may reveal the true extent of their compromise. Physical examination includes laryngeal, tracheal, and thoracic auscultation to determine the location and assess the quality of respiratory noise. Respiratory rate, mucous membrane color, and characteristics of respiratory noise. A 6-minute walk test may be carried out to evaluate the dog's ability to cope with increased activity. Thoracic radiography is indicated for assessment of the lower airway and for any concurrent problems. Thoracic radiographs are used to diagnose tracheal hypoplasia. Advanced diagnostic imaging such as CT or magnetic resonance imaging (MRI) can be used to assess airway abnormalities. Physical examination of stenotic nares and a characteristic breathing pattern can be easily recognized in patients affected by BAS (Brachycephalic Airway Syndrome). Stenotic nares, can be diagnosed through a simple physical exam. Chest radiographs are taken to look for concurrent diseases. Complete blood count and chemistry are also important to evaluate overall health. For laryngeal examination general anesthesia require. This allow us to evaluate the size of the soft palate and presence of everted saccules, normal movement of the laryngeal cartilages and other possible causes of upper airway obstruction such as a mass (Packer *et al*., 2015) [18].

14.4 Conservative management

For dogs only with mild and intermittent symptoms, BOAS can be managed conservatively by modifying the animal's lifestyle and environment, including:

- Controlling exercise levels.
- Avoiding hot and humid condition.
- Keeping the dog in an air conditioned place during the summer.
- Avoiding stress.
- Avoiding allergens.
- Avoid abesity.
- Using the harness that doesn't pull on the neck.

Corticosteroids, non-steroidal anti-inflammatory medications and oxygen therapy may all be useful for short term relief of airway inflammation or respiratory distress. However medical management does not correct the underlying anatomical abnormalities (Packer *et al*., 2015) [18].

14.5 Surgical Technique

- Rhinoplasty is the surgical method to permanently widen the externa nares (Packer *et al*., 2015) [18].
- Staphylectomy is the medical term used to describe trimming of the soft palate. It is all done at the level of the throat, inside of the mouth, and with sutures that will be absorbed after the healing is achieved (Packer *et al*., 2015) [18].
- Resection of the everted laryngeal saccules (Sacculectomy) is done, if necessary, following the palate surgical trimming (Packer *et al*., 2015) [18].
- **Tracheostomy:** An obstructed airway can be opened by means of endotracheal tube (tube which passes through the mouth and windpipe) or a tracheostomy (a surgical cut in the windpipe). Recommended treatment of laryngeal collapse is a permanent tracheostomy (Packer *et al*., 2015) [18].

15. Anaesthetic consideration of brachycephalic breeds

Brachycephalics are commonly encountered within veterinary practice and require special consideration for anaesthesia due to the anatomical abnormalities which feature in these breeds. These abnormalities include: stenotic nares, an elongated soft palate, laryngeal collapse, hypoplastic trachea and laryngeal saccule version. These abnormalities have been grouped together into what is known as brachycephalic syndrome (Downing *et al*., 2018) [5].

Anaesthesia of dogs suffering from brachycephalic obstructive airway syndrome (BOAS) should be managed using a minimal sedative premedication, pre-oxygenation and rapid intubation following induction. The problem with these dogs is often in the recovery period, as they reach a point where they are sufficiently 'light' that they will start to chew the ET tube, but not sufficiently awake that they can adequately maintain a patent airway. It is essential in these patients to realise a rapid recovery with minimal hangover, so appropriate drugs should be selected to achieve this-this means avoiding long-acting drugs (Such as acepromazine) or using only very low doses, and perhaps choosing a maintenance agent with a fast recovery profile (e.g., sevoflurane; although we use desflurane for these cases, as recovery is even faster) (Downing *et al.*, 2018) [5].

Upper airway abnormalities result in a reduction in airway diameter and an associated increase in upper airway resistance. To compensate for the latter, a greater negative intrathoracic pressure is created to generate adequate inspiratory airflow. In addition to the increase in the work of breathing, the dynamic pressure changes can further exacerbate the collapse of upper airway structures into the air passages and further increase the airway resistance. In severe cases, airway dysfunction is associated with inflammation and oedema of the pharyngeal tissues. In addition to the respiratory problems, cardiovascular and gastrointestinal abnormalities may be present in brachycephalic animals due to stenotic nares and an elongated soft palate. Brachycephalic breeds tend to learn to compensate for these respiratory insufficiencies, but sedation and anaesthesia remove these compensatory mechanisms. It then becomes the job of the anaesthetist to monitor and protect the airway (Downing *et al*., 2018) [5].

Adequate pre-anaesthesia planning for these patients is essential. The aim of the preoperative evaluation is to determine if there is any disease present that will affect the uptake, action, metabolism, elimination and safety of the anaesthetic. Primarily the cardiopulmonary, nervous, renal and hepatic are the systems of greatest concern. The history and physical examination are the best determinants of disease. Laboratory tests should only be performed on the basis of history/physical examination. It has been shown that the use of extensive laboratory screening has not improved outcome in human or veterinary medicine. Brachycephalic breeds are particularly prone to airway obstruction during the perianaesthetic period. They are prone to obstruct and die if left unattended after having been given sedatives or anesthetic drugs. Short-acting agents that leave little residual drug effect should allow these dogs to wake up rapidly and get back airway control (Downing *et al*., 2018) [5].

Deep sedation of these patients can be associated with excessive relaxation of the upper airway muscles and worsened airway obstruction. Unless a patient is aggressive or dangerous to you, use lower doses of premedications. Also note that analgesic agents should always be used for surgical procedures. Opioids are the most frequently used pre-anaesthetic analgesic agents. Opioids are not contraindicated simply because the patient is brachycephalic. Although it is thought that opioids cause respiratory depression, this is more of a dose-dependent issue. Opioids commonly used for pre-medication include: methadone, morphine, and buprenorphine (Downing *et al*., 2018) [5].

The premedication also frequently involves a sedative component in the form of an alpha-2 agonist such as medetomidine, a tranquilizer such as acepromazine, or a benzodiazepine such as diazepam or midazolam. Unlike phenothiazines and benzodiazepines, medetomidine will also provide analgesia. When combined with other medications in the premedication, dexmedetomidine may even provide sufficient analgesia and muscle relaxation for minor surgical procedures to be performed (Downing *et al.*, 2018) [5].

After proper premedication has been administered it is recommended that brachycephalic patients be "preoxygenated" prior to the administration of induction drugs. Administration of 100% oxygen before induction of anaesthesia prolongs the time to onset of arterial hypoxaemia. This technique increases the body's oxygen stores, primarily in the functional residual capacity (FRC) of the lungs. Pre-oxygenation should only, if it is not overly stressful to the patient (Downing *et al*., 2018) [5].

When intubating a brachycephalic patient, expect to use a much smaller endotracheal tube than typically used for other similarly sized patients. Carefully select a wide variety of sizes, but be ready with 2 tubes smaller than what you estimate to be the right size. A laryngoscope is a necessary tool for intubation, as the amount of redundant tissue in the pharynx may reduce the visibility of the laryngeal opening (Downing *et al*., 2018) [5].

While under anesthesia, patients can be maintained with inhaled anesthetic such as isoflurane or sevoflurane in 100% oxygen. Sevoflurane is metabolized faster than isoflurane allowing for a faster recovery. This may be an attractive choice when anesthetizing a brachycephalic patient. You can also use Propofol (3 to 19 mg/kg IV, titrated to effect and given slowly) and diazepam (0.2 mg/kg IV) that allows rapid induction, is metabolized rapidly, and does not impair laryngeal function is ideal. Propofol can cause apnea if it is given too fast; when given before propofol, diazepam may reduce the amount of propofol needed to facilitate intubation (Downing *et al*., 2018) [5].

Brachycephalic dogs have been shown to have a higher resting vasovagal tone than other breeds of dogs, which may predispose them to bradycardia. They are at risk of an arrhythmia termed sinus arrest. A sinus arrest is a pause between two normal complexes that is greater than two times the normal R to R interval due to lack of sinus node discharge. It will create on the ECG rhythm strip irregular pauses. These can be normal incidental findings, especially in brachycephalic breeds due to increased vagal tone associated with inspiration. Therefore, treatment is usually only started if the patient is clinical due to decreased cardiac output. Frequently, if the pauses are long enough, the heart's natural defense system will "escape" out of the normal pathway and initiate a beat from another region of the heart. These are then called "escape beats" or "escape rhythms" if it is a series of beats. These escape beats can either originate from around the AV node (called junctional escapes) or from the ventricles (called ventricular escapes). These beats can be differentiated

from premature beats because they will occur after the normal sinus beat would have occurred (Downing *et al*., 2018) [5].

Dogs with brachycephalic airway obstructive syndrome may also have functional and anatomic abnormalities of the gastrointestinal tract, which may predispose them to regurgitation or vomiting in the perioperative period. The postoperative surgical complication rate of brachycephalic dogs in the perioperative period has been reported to be as high as 12%, with 5% developing severe dyspnoea or death. Overall, the major concerns related to anesthesia of the patient with brachycephalic airway syndrome are the development of airway obstruction (partial or complete) at any time in the anaesthetic period (from preoperative sedation to full recovery) and the predisposition to bradycardia and regurgitation (Downing *et al*., 2018) [5].

The recovery period is an important time for the anaesthetist to stay vigilant about patient monitoring. Appropriate postoperative medications should be administered, taking into account the level of pain anticipated from the surgery performed (Downing *et al*., 2018) [5].

Brachycephalic patients should be recovered in sternal recumbency with their head slightly elevated. Avoid overly aggressive initial stimulation, as this may trigger swallowing only to be followed by a relapse into unconsciousness when the stimulation is removed. It is important to have additional induction agent and additional endotracheal tubes ready in recovery in the event that airway obstruction occurs and re-intubation is needed. Recovering these patients with supplemental oxygen is advisable; an effective option is the placement of nasal oxygen catheter during recovery. A nasopharyngeal tube can be placed and connected directly to an oxygen source to allow delivery of oxygen to the nasopharynx during recovery (Downing *et al*., 2018) [5].

Brachycephalic breeds have anatomical abnormalities that require the anaesthetist to carefully monitor breathing and any airway disturbances. However, proper premedication, vigilant monitoring in the preoperative to recovery stages, as well as a stress-free induction and recovery, can make working with these patients less challenging and more rewarding (Downing *et al*., 2018) [5].

16. Conclusion

1. Selective breeding for one desired extreme morphology can result in an unintentional pathology that is detrimental to animal health and welfare.
2. Ocular problems in brachycephalic dogs are associated with shallow orbit, prominent anterior positioned globe, excessive corneal exposure, large palpebral fissure, entropion and excessive nasal fold.
3. Small size of mouth have to fit all 42 teeth and lower jaw is longer than upper jaw leads to dental abnormality.
4. Compressed occipital and temporal bones leads to hypoplasia of the tympanic bullae predispose brachycephalic dogs to auditory tube dysfunction, fluid accumulation in the middle ear and reduced hearing.
5. Gastrointestinal (GI) problems in brachycephalic dogs are associated with BOAS and repealed when BOAS treated.
6. Excessive facial and nasal skin fold leads to skin fold dermatitis (Intertrigo) common in brachycephalic dogs due to flattened muzzle and tail pockets.
7. A corkscrew shaped tail due abnormally shaped bones in the spine (hemivertebrae) leads to instability of the spine and increased potential for compression of nerves or the spinal cord leading to pain, ataxia and loss of hind leg function in brachycephalic dogs.
8. Dystocia are observed due to the size of the puppies being born compared with the size of the mother's pelvis.
9. Upper airway obstruction is common in brachycephalic dogs so they have to work harder to breathe leads to reduce their thermoregulation ability.
10. The group of respiratory problems recognized in brachycephalic dogs as Brachycephalic Syndrome caused by stenotic nares, excess long soft palate, everted laryngeal saccules and hypoplastic trachea leads to difficulty in breathing increasing inhalation effort.
11. Vet-check systems is required to make recommendations on health concern of brachycephalic dogs.

17. References

1. Becskei C, Cuppens O, Mahabir SP. Efficacy and Safety of Sarolaner against Generalized Demodicosis in Dogs in European Countries: A non-inferiority study. Veterinary Dermatology. 2018;29:203-272.
2. Bruchim Y, Klement E, Saragusty J, Finkeilstein E, Kass P, Aroch I. Heat Stroke in Dogs: A retrospective study of 54 cases (1999-2004) and analysis of risk factors for death. Journal of Veterinary Internal Medicine. 2006;20:38-46.
3. Christiane Kadarnik C. Corneal Innervation in Mesocephalic and Brachycephalic Dogs and Cats: Assessment using *in vivo* confocal microscopy. Veterinary ophthalmology; c2008; p. 11.
4. Davis MS, Cummings SL, Payton ME. Effect of Brachycephaly and Body Condition Score on Respiratory Thermoregulation of Healthy Dogs. Journal of American Veterinary Medical Association. 2017;251:1160-1165.
5. Downing F, Gibson S. Anaesthesia of Brachycephalic Dogs. Journal of Small Animal Practice. 2018;59:725-733.
6. Ekenstedt KJ, Crosse KR, Risselada M. Canine Brachycephaly: Anatomy, Pathology, Genetics and Welfare. Journal of Comparative Pathology. 2020;176:109-115.
7. Fawcett A, Barrs V, Awad M, Child G, Brunel L, Mooney E, *et al*. Consequences and Management of Canine Brachycephaly in Veterinary Practice: Perspectives from Australian Veterinarians and Veterinary Specialists. Animals (Basel). 2018;9(1):3.
8. Feng T, Connell C, O'hara K, Chair J, Spadadofori G. Brachycephalic Breed Disease Prevalence Study; c2018.
9. Fritsche J, Spiess BM, Ruhli MB, Bollinger J. Prolapse Bulbi in Small Animals: A retrospective study of 36 cases. Tierarztl Prax. 1996;24:55-61.
10. Hale F. Stop Brachycephalism, Now! The Canadian veterinary journal = La revue veterinaire Canadienne. 2013;54(2):185-186.
11. Kelawala DN, Patil DB, Parikh PV, Sheth MJ, Joshi CG, Reddy B. Clinical Studies on Progressive Retinal Atrophy in 31 Dogs. Iran Journal of Veterinary Research. 2017;18(2):119-123.
12. Labelle AL, Dresser CB, Hamor RE. Characteristics of Prevalence of and Risk Factors for Corneal Pigmentation (Pigmentary Keratopathy) in Pugs. Journal of the American Veterinary Medical Association. 2013;243(5):667-674.
13. Marsden CD, Ortega-Del Vecchyo D, O'Brien DP, Taylor JF, Ramirez O, *et al*. Bottlenecks and Selective Sweeps During Domestication Have Increased

Deleterious Genetic Variation in Dogs. Proceedings of the National Academy of Sciences of the United States of America. 2016;113(1):152-7.
14. Marshall J. Nursing Considerations for Anaesthesia of the Obese Patient. Veterinary Nursing Journal. 2020;35(7):202-204.
15. Mielke B, Lam R, Haarter G. Tympanic Bulla Morphology; Computed Tomographic Morphometry of Tympanic Bulla Shape and Position in Brachycephalic and Mesaticephalic Dog Breeds. Veterinary Radiology and Ultrasound; c2017.
16. Miller WH, Griffen CE, Campbell KL. Muller & Kirk's Small Animal Dermatology, 7th ed., Elsevier; c2016, p. 678-680.
17. Noeller C. Computed Tomographic Anatomy of the Nose in Meso-and Brachyzephalic Cats and Potential Clinical Applications [Dissertation med. vet.]. Freie Universität Berlin; c2006.
18. Packer RM, Tivers MS. Strategies for the Management and Prevention of Conformation-Related Respiratory Disorders in Brachycephalic Dogs. Veterinary Medicine. 2015;4(6):219-232.
19. Packer RMA, Hendricks A, Burn CC. Do Dog Owners Perceive the Clinical Signs Related to Conformational Inherited Disorders As 'Normal' For the Breed? A Potential Constraint to Improving Canine Welfare. Animal welfare. 2012;21:81-93.
20. Patel KP, Parikh PV, Mahla JK, Ashwath SN, Kelawala DN. Incidence of Corneal Ulcer in Dogs-Retrospective study. International Journal of Current Microbiology and Applied Sciences. 2020;9(8):3174-3179.
21. Peeters ME. Pyloric Stenosis in The Dog: Developments in its surgical treatment and retrospective study in 47 patients. Tijdschr Diergeneeskd. 1991;(116):137-141.
22. Pollinger JP, Bustamante CD, Fledel-Alon A, Schmutz S, Gray MM, Wayne RK. Selective Sweep Mapping of Genes with Large Phenotypic Effects. Genome Research. 2005;15(12):1809-1819.
23. Ryan R, Gutierrez-Quintana R, Haarter G. Prevalence of Thoracic Vertebral Malformations in French Bulldogs, Pugs and English Bulldogs with and Without Associated Neurological Deficits. Veterinary Journal. 2017;221:25-29.
24. Sanchez RF, Haar GT. Brachycephalic Breeds of Dog are Increasingly Popular with Pet Owners, But They Have Certain Anatomical Features That Predispose Them to Various Problems. Small dog-Big dog-Veterinary Focus. 2017;27(3):15-22.
25. Schlensker & Distl. Prevalence, Grading and Genetics of Hemivertebrae in Dogs. European Journal Companion Animal Practice. 2015;23:119-123.
26. Schoenebeck JJ, Ostrander EA. The Genetics of Canine Variation Skull Shape. Genetics. 2013;193(2):317-325.
27. Stades FC, Van de Sandt RR, Boeve MH. Clinical Aspects and Surgical Procedures in Trichiasis. Tijdschr v Dierg. 2007;118:385-395.
28. Tseng LW, Drobatz KJ. Oxygen supplementation and humidification, In: Textbook of Respiratory Disease in Dogs and Cats, (Ed.) WB Saunders, Philadelphia USA; c2004, p. 205-213.
29. Universities Federation for Animal Welfare. Dystocia Due to Foetal-Pelvic Disproportion in English Bulldogs; c2011.
30. Van Der Woerdt A. Adnexal Surgery in Dogs and Cat. Veterinary Opthalmology. 2004;7:284-290.
31. Venker-van Haagen AJ. The Ear. Ear, Nose, Throat and Tracheobronchial Diseases in Dogs and Cats; c2005, p. 1-50.
32. Wang M, Song Q, Xu J, Hu Z, Gong Y, Lee AC. Continuous Support During Labour in Childbirth. BMC Pregnancy Childbirth. 2018;18:480.