
DIAGNOSIS AND TREATMENT OF CANINE CHRONIC BRONCHITIS

Twenty Years of Experience

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In the early 1970s, Chakrin and Saunders² stated that spontaneous chronic bronchitis (CB) rarely occurred in dogs. At about the same time, and patterned after the accepted definition in human medicine, Wheeldon et al¹² proposed a definition of canine chronic bronchitis based on the clinical and pathologic findings they obtained from a series of 26 dogs with spontaneous CB. The definition, specifically that of chronic coughing occurring for 2 consecutive months during the preceding year and which was not attributable to another cause (e.g., neoplasia, heartworm, congestive heart failure [CHF]), has stood the test of time and is now used as the basis for making the clinical diagnosis of CB in small animal veterinary medicine. Today, CB is considered to be one of the most common chronic respiratory diseases of dogs.

Chronic bronchitis is a frustrating disease because the inciting cause is rarely ever determined; because the pathologic changes that accompany and define the disease are typically nonreversible and often slowly progress to more life-threatening disorders; and finally, because there is still little direct scientific evidence for the treatment recommendations that have been offered for the management of this disease in dogs.

PATHOPHYSIOLOGY

Experimentally, CB can be induced in dogs following exposure to various inhaled irritants, including sulfur dioxide and cigarette smoke.

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These animals demonstrated similar clinical findings (spontaneous coughing, crackles on auscultation, excess mucus) and pathologic changes (squamous metaplasia of the tracheobronchial epithelium, an increase in goblet cell numbers, glandular hypertrophy, mucosal inflammation, and polypoid mucosal proliferations) as were described in the series of spontaneously occurring CB in dogs by Wheeldon et al.¹²

The exact cause of spontaneously occurring canine CB is usually unknown but inhaled irritants, recurrent low-grade infections, and smoldering inflammation (bronchitis, after all, is ongoing inflammation) are thought to be the major factors that favor the progression of this disease. Airway inflammation is accompanied by cellular infiltrates, mucosal edema, glandular hypertrophy, goblet cell hyperplasia, and loss of ciliated epithelial cells. All of these contribute to airway narrowing or obstruction, changes in lung mechanics (increased lung resistance and decreased compliance), altered ventilation-perfusion ratios, and eventually clinical hypoxemia. In severe cases, this chronic inflammatory process may eventually progress to irreversible structural changes in the airways (e.g., softening of the cartilaginous support of the airways—tracheobronchial malacia; dilation of airways caused by scarring—bronchiectasis), which further interfere with gas exchange and secretion clearance. Retained secretions obstruct airways and may also predispose to future infections and pneumonia.

CLINICAL PRESENTATION

Although Wheeldon's original study group was composed of primarily terrier and small-breed dogs, it is accepted that medium-sized dogs are also commonly diagnosed with CB. All breeds are affected, but West Highland White terriers and Cocker Spaniels seem to be more severely affected. Affected animals are usually middle aged or older, and there is no sex predisposition. Obese animals are common and may present with more severe signs of respiratory distress.

The hallmark of CB in dogs is chronic coughing. The cough is dry to moderately productive depending on the amount of mucus in the airways. Owners frequently complain of post-tussive retching or gagging as secretions are brought up the trachea and cleared through the larynx. Exercise intolerance, tachypnea, cyanosis, and syncope may be seen in severe cases. Systemic signs (fever, anorexia, depression) are uncommon unless secondary problems (pneumonia) develop.

Physical examination typically reveals a bright, alert, and responsive animal. If untreated, an increased tracheal sensitivity is almost always present, and the resulting cough is a dry or harsh-sounding cough. Lung auscultation may reveal increased adventitious sounds including bronchovesicular sounds, crackles, and wheezing. An expiratory snapping sound is often heard if the pressures generated during the act of coughing result in tracheal or main stem bronchial collapse. If tracheobronchial malacia is severe or if extensive small airway disease is pres-

ent, an *expiratory* effort may be noted during quiet breathing. This abdominal push may be seen, ausculted, or palpated in most cases; its presence should raise a red flag of caution in these dogs, as respiratory distress may be easily induced.

Many small-breed dogs routinely develop lesions of valvular endocardiosis as they age and may present with an auscultable murmur. The history of coughing and the presence of such a murmur, however, do not automatically equal CHF. The clinician is frequently faced with the problem of trying to differentiate between CB and CHF. The failing heart responds in part by increasing heart rate to maintain cardiac output; typically, dogs present in CHF with heart rates well above 150 to 180 beats per minute. Dogs with CB, on the other hand, typically present with a resting heart rate in *the normal to slightly slower than normal range* for the breed. Obtaining a resting heart rate is a simple method of assisting in making this differentiation.

Other physical findings of importance include the body condition score (a clinical measure of the animal's actual weight versus their ideal body weight) and whether there is any concurrent periodontal disease. Obese animals have a tendency toward more airway obstruction and respiratory distress, because closing volume (the lung volume where airways close during expiration) is reached more readily in these animals, and compliance (the "stretchability" of the lungs) decreases with morbid obesity. It was shown that a 5% weight loss in obese children is associated with a significant improvement in pulmonary function tests. Improvement in lung function and clinical signs can be achieved in obese dogs with CB with weight loss alone, and in those animals it is an important part of the author's client education. It is unfortunate that dental disease is sometimes not treated aggressively in older dogs. Often, the age of the animal or the presence of a murmur are quoted as reasons for avoiding the required anesthesia and full dental cleaning procedure. Bronchitic dogs' airways are constantly bombarded with debris from a severely infected oral cavity. These patients are at risk for developing an acute bacterial infection (e.g., pneumonia or endocarditis) on top of their chronic airway inflammation or valvular insufficiency. Although anesthesia is of concern in older patients, maintaining a healthy oral cavity is essential in maintaining a healthy cardiopulmonary system.

DIFFERENTIAL DIAGNOSES

Other common causes of coughing in the dog include bronchiectasis, pneumonia (allergic, bacterial, fungal), heartworm disease, cardiac disease, and neoplasia.

DIAGNOSTIC EVALUATION

Although a cause is not determined in most cases, a complete diagnostic evaluation is important in finding those cases that do have a

specific cause and predicting the severity and future progression of the airway disease for the owner. The latter is extremely important in obtaining compliance with treatment and management recommendations made subsequently.

Clinical Pathology

Routine clinical pathology (including a full complete blood count, serum chemistry, urinalysis, and fecal examination) does not often identify the cause of CB but frequently helps identify other concurrent disorders that affect future treatment or diagnostic choices. In some areas of the country, larval migration is a common cause of airway hypersensitivity, and fecal examinations may document the presence of some of these intestinal parasites. Heartworm serology should be used to evaluate the coughing dog in endemic areas or when travel history is compatible with potential exposure. Arterial blood gases are discussed in the section on pulmonary function testing.

Chest Radiography

Chest radiographs are an important tool in the diagnosis of CB. The author uses these findings to help exclude other causes of coughing (CHF, neoplasia, heartworm disease, and so forth) and to look for the classical radiographic patterns associated with CB. The typical radiographic findings of canine CB include increased bronchial markings ("doughnuts" and "tram lines"), a mild diffuse increased interstitial density, and rarely, hyperinflation or air trapping (this is more common in the cat). The author prefers to take left and right lateral views as well as ventrodorsal (VD) or dorsoventral (DV) radiographs. The extra views help in visualizing subtle lesions or lung changes. If dynamic airway changes are suspected (tracheal or mainstem bronchial collapse), inspiratory and expiratory radiographs should be obtained at the peak of the respective respiratory cycles. The VD radiograph is also helpful in demonstrating overall lung volume and chest wall thickness in obese animals, and when compared with chest radiographs from a nonobese dog, these radiographs are extremely useful in demonstrating this problem to owners. It is important to remember that the degree of structural changes in the lungs (what radiographs show) may not correlate with the functional abnormalities that a patient with CB shows clinically. Many cases with severe airway changes on bronchoscopy have minimal radiographic changes on the thoracic radiographs.

Culture and Cytology

Culture and cytology of airway fluid samples are critical in the evaluation of canine CB. There are two major methods of obtaining

airway secretions: performing a transtracheal wash (TTW) or obtaining a bronchoalveolar lavage (BAL) during bronchoscopy. The major differences between the procedures are summarized in Table 1. The visual information gained during bronchoscopy is of major value in the overall diagnosis, prognosis, and treatment of the case. Bronchoscopy with a BAL sample far exceeds the diagnostic value of a simple TTW procedure.

A third technique that has been used to collect airway cytology is bronchial brushing. The author does not recommend this procedure, because the cytology obtained tends to contain more basal cells, which are more reactive-appearing and can be difficult to interpret. Cultures using a bronchial brush are also more difficult to handle. Techniques for collecting BAL fluid using a catheter passed through an endotracheal tube or directly through the endotracheal tube have been described but are not nearly as rewarding as the bronchoscopy-guided BAL sample.

Airway cytology from CB animals generally shows an increased number of PMNs; in some instances, this finding is misinterpreted as being indicative of suppurative (implying bacterial even though no bacteria are observed) inflammation when in fact it is simply a reflection of the ongoing inflammatory airway process. Other cells that are commonly encountered include eosinophils and macrophages. The presence of pulmonary macrophages implies that the sample contains cells from the distal airways (a good finding); macrophages are the predominant cell type (60 to 80%) on canine BALs. The presence of squamous epithelial cells or *Simonsiella* bacteria (a common inhabitant of the oral cavity)—indicate likely oropharyngeal contamination, and any interpret-

Table 1. COMPARISON OF TWO MAIN TECHNIQUES USED TO OBTAIN AIRWAY SAMPLES FROM ANIMALS WITH CHRONIC BRONCHITIS

	BAL During Bronchoscopy	Tracheal Wash*
Advantages	Direct visual assessment of the mucosal, anatomic, and functional changes in the airways; ability to obtain tissue biopsy if indicated and also to retrieve a foreign body	Less anesthesia, equipment, and cost; technique is easily learned
Disadvantages	Requires general anesthesia; more training and more equipment; higher costs involved	Lacks ability to visualize the airways; unable to obtain samples from specific sites
Airway cytology	Represents the smaller, more distal airways and the interstitial tissue. Normal ranges for total and differential counts have been established	Represents exfoliated cells that have accumulated in the tracheobronchial mucus. Quantitative analysis is not performed

BAL = bronchoalveolar lavage.

*This may be performed through the trachea (transtracheal) or by way of a catheter passed down a preplaced sterile endotracheal tube.

tation from cytology or culture should be made cautiously. Interpretation of the cytology findings also depends on knowing how the sample was collected; there often is a difference in the cytology findings obtained from TTW, BAL, and brushing. Hawkins et al⁴ showed that airway cytology differed in 68% of the cases when TTW and BAL samples were compared; BAL is a more reliable indicator of airway disease.

Based on studies by Padrid et al⁸ and more recently by Peeters et al,⁹ cultures from these cases are often negative and should be performed using a quantitative technique. There is certainly precedent for this recommendation in veterinary medicine; urine cultures are routinely performed using quantitative techniques to determine whether bacterial growth is significant. Most canine CB cases do not have an active bacterial infection at the time of diagnosis. In the study of Dye et al³ comparing healthy and bronchitic cats, there were higher numbers of bacteria recovered from the healthy cats than from the bronchitic cats. In the past, light or nonsignificant colony counts were obtained and misinterpreted as representative of airway infection. A quick and easy method of assessing airway infection is to evaluate the BAL fluid for intracellular bacteria while performing the routine cytology and differential cell count and performing a Gram's stain on the sample. Peeters et al⁹ showed that more than three intracellular bacteria per 50 oil fields is likely to be associated with significant bacterial growth on final culture. They determine that significant bacterial growth in dogs with CB is indicated by more than 2.7×10^3 colony-forming units.

Bronchoscopy

Bronchoscopy not only provides a selective means of collecting airway fluid for cytology and culture but also allows for the visual assessment of the entire length of the respiratory tract. Changes encountered during bronchoscopy may involve structural abnormalities of the upper airways (larynx, trachea) or lower airways (trachea, lobar, and segmental bronchi) and some conditions outside the airways themselves (hilar lymphadenopathy, left atrial enlargement, and bronchial compression). Functional abnormalities, such as tracheobronchial malacia or collapse and bronchiectasis, may also be detected. Table 2 summarizes many of the findings that are commonly encountered during bronchoscopy in chronic bronchitic dogs. The reader is referred to the reference list for articles on performing bronchoscopy in the small animal patient.^{5,6}

Pulmonary Function Testing

Pulmonary function testing has been used in human medicine for decades to measure pulmonary mechanics (resistance and compliance) but has only recently been used in veterinary clinical practice (and then only at selected universities). The equipment required for these

Table 2. BRONCHOSCOPIC FINDINGS THAT MAY BE ENCOUNTERED IN DOGS WITH CHRONIC BRONCHITIS

Site	Mucosal Changes	Anatomic Changes	Functional Changes
Upper airways (soft palate, larynx, cervical trachea) may be abnormal in up to 30% of CB cases	Inflammation, hyperemia, edema, irregular or mottled surface, excess secretions	Elongated soft palate; laryngeal and saccular edema; saccular eversion; laryngeal collapse, tracheal collapse	Soft palate or epiglottic entrapment (into the laryngeal or glottic opening); laryngeal collapse; laryngeal paralysis, collapse involving a redundant tracheal membrane
Tracheobronchial tree (intrathoracic trachea, large and small bronchi)	Inflammation, hyperemia, edema, irregular or mottled surface, epithelial polyp formation, accumulation of excess secretions, bleeding	Collapse, hypoplasia, external compression, stricture, bronchiectasis, web formation or scarring across smaller airways; parasites (nodules of <i>Oserlus osleri</i> infection; <i>Paragonimus</i> flukes)	Malacic airways (involving the trachea, bronchi, or distal airways) may collapse during normal respiration and completely during forced (cough) respiratory efforts
Extrabronchial structures	NA	Hilar lymphadenopathy may compress one or more bronchi; prominent or enlarged pulmonary arteries may push into the bronchial lumen	Enlarged left atrium may compress the left principal bronchus

diagnostic tests is becoming more available and may be seen in some larger clinical practices in the future. Some of the tests that have been used in small animal medicine include the tidal breathing flow volume loop,⁵⁻⁸ measures of resistance and compliance,^{3,10} and recently the development of an unrestrained, barometric whole-body plethysmography technique for the measurement of airway resistance in cats.¹¹ It remains to be seen which of these techniques might become available to the practitioner in the future.

Measurement of arterial blood gases (ABG) is a basic pulmonary function test and one that is routinely available to the practicing veterinarian. This simple test allows for objective measurement of alveolar ventilation (P_{aCO_2}) and oxygen exchange (P_{aO_2}), calculation of the overall efficiency of gas exchange (the difference between alveolar and arterial P_{aO_2} ; the DA- aO_2 gradient), and determination of the patient's acid-base status. Changes in the patient's ABG demonstrate changes in lung function before clinical and radiographic changes typically become apparent;

ABGs are one of the easiest ways to monitor pulmonary disease. With the advent of small, portable arterial blood gas analyzers, measurement of ABGs is regularly available in larger practices or through the laboratory at a local hospital. Samples are easily obtained using a small (1 to 3 mL) heparinized syringe and a 23- to 25-gauge needle. The femoral and dorsal pedal arteries are most commonly used. Normal ABG values (measured at sea level) are pH of 7.35 to 7.45, PaCO₂ of 35 to 40 mm Hg (excitement typically lowers this into the low 30s), PaO₂ of 90 to 100 mm Hg, and HCO₃ of 24 ± 3 mEq/L. Hypoxemia in a dog can be defined as a PaO₂ of less than 80 mm Hg on room air at sea level (values are less at altitude). Continued hypoxemia can lead to hypoxic vasoconstriction and the potential for the development of pulmonary hypertension and *cor pulmonale*. ABG measurements are useful in determining the severity of CB when it is first diagnosed and in monitoring the response to treatment over time.

TREATMENT

Canine chronic bronchitis is a frustrating disease to treat and one that owners must learn to live with and manage. It should usually be thought of as a self-perpetuating, slowly progressive, noncurable disease. Environmental concerns in the animal's home include smokers in the house, the presence of forced air heating or cooling (potential for dirty ducts or filters), wood-burning stoves or fireplaces, and the use of room deodorizers or carpet cleaners, among others. Eliminating any of these potential sources of airway irritation ("trigger situations") can only be helpful with the long-term control of the clinical signs. Getting owners to appreciate these concepts greatly improves their understanding of the disease and the long-term management and treatment that is required. They should understand that with CB, the cough will never be controlled 100% of the time; rather, with appropriate therapy, it can be reduced to a point where both the owners and the animal are comfortable with the dog only coughing occasionally.

Obesity is extremely common in our canine population. Excess weight results in reduced lung volume, changes in lung compliance, and respiratory distress (panting, hypoxemia, exercise intolerance). Weight loss through appropriate dietary control is one of the more effective management techniques for dogs with CB. Endocrine causes of obesity should be closely evaluated (e.g., hypothyroidism) and treated if indicated. The patient's weight should be closely monitored during treatment and owners encouraged in their attempts to help their pets achieve a normal weight.

The major points that this discussion on therapy addresses are the coughing, ongoing airway inflammation, airway obstruction and narrowing, hypoxemia, and the potential for secondary infections to develop. Specific sequelae to chronic coughing, including bronchiectasis

and the development of *cor pulmonale* (caused by pulmonary hypertension), are not discussed.

An obvious choice for treating chronic coughing is the use of an antitussive. The author tries to suppress coughing when it is nonproductive, paroxysmal, and irritating to the dog (and owner). Antitussives should not be used when there is pneumonia or a productive cough, because secretion retention is a serious problem. In my experience, these agents are useful but, by themselves, not as effective in controlling the cough as is directly treating the inflammation that is triggering the cough reflex. Examples of recommended antitussives are given in (Table 3).

Effective treatment starts with the use of corticosteroids to suppress the ongoing airway inflammation. My preference is to use oral medications, specifically prednisone or prednisolone. If airway cytology is suggestive of an infection (increased numbers of PMNs and intracellular bacteria), steroid use should not be started until final culture results conclude whether there is an infection present or not. The initial dosage depends on the severity of the airway inflammation and is based on the bronchoscopic findings or at least on the presence of typical history and physical findings of CB. Typically, these dogs are started at 0.5 to 1 mg/kg every 12 to 24 hours for 1 to 3 days and rapidly tapered down to alternate-day dosing at approximately 0.25 mg/kg. The final dose varies among patients, with changes in the seasons and other things such as the pollen count, ozone level, or the presence of one or more of the other irritants discussed previously. The author tries to get the dog's owners to understand that the clinical severity of their pet's disease will vary over time and that they should feel comfortable in varying the prednisone dose to maintain control of the coughing. The obvious side effects associated with the higher doses of prednisone (increased appetite, water intake, urination, panting, behavior, and concerns about possible immunosuppression and weight gain, among others) must also be explained to the owner. Usually these side effects are only of concern early in the course of treatment when the higher doses are being administered.

Recently, there was some discussion at continuing education meetings, on the Internet, and among those dealing with respiratory cases about the efficacy of inhaled medication, including steroids or bronchodilators, in small animals (see the article elsewhere in this issue on feline asthma by Padrid). Clearly, the advantage, inferred from human medicine, is that potential adverse side effects from systemic therapy can be nearly completely eliminated while delivering the medication to the affected site. Unfortunately, to the author's knowledge, there are no controlled studies on the clinical application of this approach to date, yet interest in this idea continues to grow. The limitations to this form of treatment are timing of the dose (inhaler "puff") so that it coincides with the patient's inspiration and the fact that some form of face mask must be used to deliver the dose to the animal's nose. It is well known that the best deposition of aerosolized medications into the lower airways is when a patient is breathing orally using slow, deep breaths with an end-inspiratory breath hold. Even in human medicine and with this

Table 3. ALPHABETICAL LISTING OF RECOMMENDED DRUGS FOR THE TREATMENT OF CANINE CHRONIC BRONCHITIS

Drug Category	Indications	Contraindications	Common Examples and Canine Doses
Antibiotics	Airway infection (quantitated culture); pyorrhea	Known sensitivity to the drug	Amoxicillin/clavulanic acid, 10–20 mg/kg PO BID–TID Cephalexin, 22 mg/kg PO TID Doxycycline, 2.5 to 5 mg/kg PO BID Fluoroquinolones—various, full dose given SID Others
Anti-inflammatory	Airway inflammation, allergic airway disease	Respiratory tract or other infection, endocrine disorder (e.g., diabetes)	Prednisone or prednisolone, 0.5 to 1 mg/kg PO SID–BID for 1–3 days, then taper to alternate-day dosing of approximately 0.25 mg/kg
Antitussives	Dry, nonproductive, irritating cough	Pneumonia or the presence of excess secretions	Butorphanol, 0.5 to 1.0 mg/kg BID–QID Codeine, 1 to 2 mg/kg PO BID–QID Hydrocodone, 0.5–1.0 mg/kg PO BID–QID
Bronchodilators	Reversible airway disease, active expiratory effort, chronic coughing, exercise intolerance	Caution in dogs with primary heart disease	β_2 agonists: Albuterol, 20 to 50 μ g/kg PO BID–TID (increase slowly) Terbutaline, 1.25 to 5 mg/dog PO BID Sustained-release theophylline: Slo-bid Gyrocaps (Rhône-Poulenc Rorer), 25 mg/kg PO BID Theo-Dur tablets (Key Pharmaceuticals), 20 mg/kg PO BID

PO = by mouth; BID = twice daily; TID = three times a day; QID = four times a day; SID = once a day.

sort of special training for the individual, studies show that there is a high percentage of individuals who still dose themselves incorrectly. It should be of no surprise that the ability to accurately deliver an inhaled dose of medication to a small animal by way of a face mask must be called into question. Despite this, there have clearly been cases where an inhaled medication has appeared to improve the patient's airway disease. This form of treatment will continue to be scrutinized and delivery systems modified in an attempt to determine if this may become a viable method of dosing animals whose disease is either not controlled or who have unacceptable side effects from systemic medications.

The author routinely uses oral bronchodilators in the treatment of canine CB. Bronchodilators are indicated when there is reversible airway disease (inflammation resulting in some degree of bronchospasm). Unfortunately, because pulmonary function testing is not routinely available, confirming the reversibility of airway disease is not possible (a previous study⁸ using pulmonary function tests suggested that only one in seven dogs with CB had clinically significant, reversible bronchoconstriction). As a consequence, the author relies on clinical indications and response to a therapeutic trial to decide whether bronchodilators are continued. The presence of chronic coughing and exercise intolerance are two historical findings looked for in deciding whether to use bronchodilators. Physical findings include tracheal sensitivity, crackles on auscultation, and especially signs suggestive of small airway obstruction (specifically an active expiratory effort—abdominal push—while breathing at rest). Systemic bronchodilators include the methylxanthines (theophyllines) and the β_2 agonists. Albuterol and terbutaline are the β_2 drugs of choice for dogs. Aminophylline, the soluble salt of theophylline, has relatively poor pharmacokinetics in dogs and should not be used. There are over 30 sustained-release theophylline products on the human market; only a handful of these have been evaluated in dogs. Of the ones evaluated, only two of these (Table 3) were shown to have appropriate pharmacokinetics for use in dogs. It is important that generic theophyllines not be substituted, because their kinetics are unknown, and in some instances, their use has resulted in signs of clinical toxicity.

Airway infection (defined as greater than 2.7×10^3 colony-forming units on quantitative culture results) is uncommon in canine CB; however, because of the presence of excess secretions and poor clearance mechanisms, secondary infections do occur. Opportunistic organisms, including common oropharyngeal flora, may be involved. Severe dental disease is a common finding in older dogs, and it is often considered to be a potential source for lower airway infection. Secondary pneumonia may develop and can be life-threatening. The author prefers to use a bactericidal, broad-spectrum antibiotic, especially one that is active against gram-negative bacteria. Antibiotics that achieve high concentrations in the lung (fluoroquinolones, doxycycline) are particularly good choices (see Table 3).

Surgery may be indicated in selected cases of CB that have coexisting airway disorders such as stenotic nares, elongated soft palate, edema-

tous or everted laryngeal saccules, and perhaps cervical tracheal collapse. Correction of these airway disorders may improve respiratory signs and reduce the animal's overall respiratory distress.

PROGNOSIS AND POTENTIAL COMPLICATIONS

Chronic inflammation may lead to permanent structural changes in the airways and, in severe cases, clinical signs or changes in other organs. Chronic coughing may lead to cough syncope (secondary to decreased blood flow into the central nervous system), hypoxemia, and right heart hypertrophy secondary to pulmonary hypertension (*cor pulmonale*) or bronchiectasis and recurrent pneumonia. Early diagnostic and therapeutic interventions are strongly recommended to attempt to prevent this damage from occurring.

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