c. when food is aspirated into the respiratory tract.

d. within the context and presence of an existing serious illness.

3. The phagocyte in the immune system that specifically locates and destroys bacteria is

a. the white blood cell

b. cortisol

c. the neutrophil

d. the hematocrit

4. How does the stress response to seriously acute illness affect the oropharyngeal and tracheobronchial environments?

a. It increases salivary and mucous production which enhances the immune system's protection of the epithelium.

b. It reduces sensation to the muscles and epithelial surfaces due to restricted blood supply.

c. It reduces salivary and mucous production which reduces the immune system's protection of the epithelium.

d. It reduces salivary and mucous production which reduces lubrication of the oral cavity and impairs bolus formation and propulsion.

5. Aspiration pneumonia can only develop

a. when food carrying a concentrated bacterial load passes through the larynx.

b. when food passes through the larynx and reaches the trachea and bronchi.

c. when any contents carrying a concentrated bacterial load from the oropharynx or from the stomach pass through the larynx into an immune-compromised lower respiratory tract.

d. the red blood cell count is high and the white blood cell count is low.

Stroke Patients and Aspiration Pneumonia

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Epidemiology of Stroke

Stroke is one of the most common and devastating clinical disorders that can affect any person. A stroke is characterized by the sudden and rapid development of clinical symptoms and signs due to focal or global loss of cerebral function that lasts more than 24 hours or leading to death within that period. In all clinical cases there is no apparent cause other than that of vascular origin (Hatano, 1976).

In the United Kingdom (UK), more than 100,000 people each year suffer their first stroke. Worldwide, after myocardial infarction and cancer, stroke is the third most common cause of death (Thorvaldsen, Asplund, Kuulasmaa, Rajakangas, & Schroll, 1995). The annual incidence of first stroke without adjustment for age, gender or race is calculated to be approximately 2.4/1,000 head of population. This rises with increasing age, such that the incidence for those aged over 85 years is 10 per 1,000 head of population (Wade & Hewer, 1987). In the UK, stroke causes an estimated 60,000 deaths per annum (ONS Mortality Statistics Cause, 1997). In the UK, the cost of strokes to the National Health Service (NHS) is estimated to be at least £2.3 billion per annum, with at least 25% of long term and 20% of acute care beds being occupied by patients following a stroke.

While these statistics show that stroke is an ever increasing problem worldwide, it may still be a gross underestimate, as some authors such as Leibson and colleagues (1998) have found that as many as 45% of stroke patients are never admitted to a hospital and, thus, may not be identified in statistical summaries. In addition, sudden death may not be attributed to an underlying stroke, and direct admission to a nursing home may never be coded as an incident case of stroke.

While some of the additional financial impact of stroke is due to long-term care, most of the resultant increased costs are due to greater requirement for acute care and rehabilitation, rather than long-term care. It is well documented that 74% of patients still need some help with activities of daily living such as washing, dressing, and feeding themselves even 3 months after stroke (Dewey et al., 2002).

Pathophysiology of Stroke

A stroke occurs when the blood supply to part of the brain is interrupted. The majority of strokes are due to the blockage of an artery by either clot or plaque within the vessel. A smaller but significant number of strokes are due to hemorrhage from a ruptured vessel that results in a dependent area of brain tissue being deprived of its supply of oxygen and nutrients, thus becoming necrotic. Whatever the underlying pathophysiology, functions that were normally supplied by that area of brain tissue are therefore lost.

Clinical Features

All clinical symptoms and signs depend on the areas of the brain that are affected by the stroke, irrespective of whether an infarct or a hemorrhage has occurred. These include paralysis of the limbs and trunk on one side of the body, an inability to speak or understand speech and problems with swallowing and/or vision. Immediately following a stroke there may be altered levels of consciousness with patients being very drowsy or even unconscious.

Dysphagia in Stroke

One of the most common consequences of stroke is dysphagia. This may occur in as many as 60% of patients (Mann, Hankey, & Cameron, 1999). The majority of patients who suffer from dysphagia do so immediately following the stroke, although a small group of patients whose swallow is initially unaffected will develop dysphagia at a later stage (Smithard et al., 1997). Dysphagia that is present immediately following a stroke is found to resolve in half of all patients, although a small group of patients in whom dysphagia persists for more than 3 weeks are generally found to have a less favorable outcome (Barer, 1989). Patients with dysphagia have increased levels of disability, longer duration of hospital stay, and have a greater need for subsequent institutional care, as well as increased death rates (Smithard, O'Neill, Parks, & Morris, 1996). Following a stroke, the most common abnormality in swallowing is a delayed swallow followed by reduced pharyngeal peristalsis and poor tongue control. Veis and Logemann (1985) suggested that swallow dysfunction could not be explained by a single malfunction, but that there are always several areas of abnormality. Daniels, Ballo, Mahoney, and Foundas (2000) identified six clinical indicators that distinguished stroke patients who were at increased risk of aspiration. They implicated abnormal cough, abnormal gag reflex, dysphonia, dysarthria, voice change, and cough after swallow. In contrast to Daniels and colleagues (2000) that looked at patients with dysphagia, Martin and colleagues (1994) studied the ability to swallow in patients who had already developed aspiration pneumonia. Their group found, not surprisingly, that the more severe the dysphagia was, the more likely the patient would be to develop a chest infection. They found that the development of aspiration pneumonia also depended on the frequency, character, and volume of material aspirated as well as the efficiency of the patient's pulmonary defenses.

It is easy to suggest that all patients who have dysphagia aspirate and that all patients who are free from symptoms or signs of dysphagia have an entirely safe swallow. Videofluoroscopy is a well-known technique that helps provide evidence of aspiration in patients with or without symptoms of dysphagia. Ding and Logemann (2000) studied patients following a stroke who were referred for videofluoroscopy studies because of swallowing problems. They showed that 48-55% of this patient group aspirated and those patients who did aspirate were more likely to develop pneumonia. They found that the highest incidence of aspiration was in those patients with multiple strokes, followed by those with brainstem or sub-cortical strokes. They also correlated the incidence of pneumonia with stroke location and found that patients who developed pneumonia were more likely to have multiple location strokes or to have an unspecified location. It may, however, be difficult to entirely exclude any underlying cognitive problems as the cause of aspiration or pneumonia in those patients who have multiple areas of pathology within the brain.

Other authors have not found such a high incidence of aspiration. Teasell, McRae, Marchuk, and Finestone (1996) described pneumonia as an "uncommon" complication of stroke. They found it to occur in 2.7% of all stroke patients in their trial, but of those patients who aspirated pneumonia was found in 12%. In keeping with some of the data of Ding and Logemann (2000), they found that right-hemisphere or brainstem strokes were most likely to result in aspiration, dysphagia, and aspiration pneumonia.

For aspiration pneumonia to develop, three conditions must be met: (a) material must be aspirated, (b) the aspirated material must contain a respiratory pathogen, and (c) the respiratory pathogen must be able to overwhelm the patient's defense mechanisms.

In the case of patients following a stroke, the aspirated material considered most important in the causation of pneumonia is saliva. In dysphagia there is a tendency for saliva to remain in the mouth for longer than usual as patients with dysphagia may swallow smaller volumes and less frequently than patients without dysphagia.

Swallow Screening

While a variety of screening procedures have been described in the literature, the majority are designed predominantly to detect aspiration. Most assessments involve a pre-swallow assessment. Factors correlated to swallowing safety include level of consciousness, voice quality, dysarthria, and voluntary cough. The patient is asked to swallow different amounts of water from a cup or glass and observed for clinical signs of aspiration such as voice changes, coughing, delayed swallow, or respiratory distress. The clinician then makes a judgement about the presence or absence of dysphagia based on observation of the above (Daniels, Bailey, & Foundas, 1997; Ellul, 1996; Smithard et al., 1997). While the use of a water swallow test is a reliable detector of penetration or aspiration (McCullough et al., 2000), it has been questioned, as it may potentially put patients at risk of aspiration (Logemann, Veis, & Colangelo, 1999).

Tracheal pH Monitoring

Tracheal pH monitoring is a test first developed in Liverpool by Donnelly and Berrisford (1993). The procedure involves the placement of a small pH electrode only 1.5 mm in diameter into the trachea through the cricothyroid membrane under local anaesthetic. The probe subsequently remains in this position for up to 24 hours, thus allowing prolonged monitoring of the patients. It has subsequently been found that, even in the absence of videofluoroscopic or clinical indication of aspiration, tracheal pH indicates the aspiration of acid stomach contents into the trachea in stroke patients (Clayton, Gosney, & Jack, in press; Jack, Walshaw, Tran, Hind, & Evans, 1995).

Oral Flora/Colonization/ Isolation

An unhealthy oropharynx can easily be distinguished by the nature of its bacterial flora (van Saene & Stoutenbeek, 1992). The normal oropharyngeal flora consist predominantly of facultative gram-positive bacteria such as alpha hemolytic streptococci, with aerobic gram-negative bacteria (AGNB) being found as transient residents only. Isolation is the presence of a bacterium on one isolated occasion, whereas carriage is the presence of a bacterium on two consecutive samples. When normal flora are present, they perform four functions which help to prevent colonization by potentially pathogenic bacteria:

1. Occupy receptor sites on oral mucousa thereby inhibiting adherences by AGNB,
2. Consume the available nutrients thereby "starving out" AGNB,
3. Produce substances that are actively toxic to AGNB, and
4. Promote normal physiologic processes including mucosal cell renewal which contributes to clearance of AGNB.

Both age and pathology influence oral flora. While the healthy individual can resist AGNB, the acutely ill patient often finds the oropharynx colonized and, if aspiration occurs, pneumonia may be the final event (Gosney, Preston, Corkhill, Millns, & Martin, 1999; Millns, Gosney, Martin, Jack, & Gow, 1999). The oral flora can be changed by both local and systemic illness (Preston, Gosney, Noon, & Martin, 1999). Therefore, dental decay and oral disease may result in pathogenic bacteria being found in large numbers. In addition, individuals who have been immuno-compromised by malnutrition or illness, such as stroke or Parkinson's disease, may be colonized as the pathogenic bacteria meet little patient resistance (Millns et al., 1997; Punekar, Pearce, Martin, Playfer, & Gosney, 1999).

While only 6% of healthy individuals carry AGNB, this rises to 37% among moderately ill and 73% in seriously ill patients (Mackowiak, Martin, Jones, & Smith, 1978). In unhealthy individuals, the oropharynx may be found to be colonized by AGNB. Not all AGNB are considered to be pathogenic, since healthy individuals may carry them transiently from as early as day 2 of life (Rotimi & Duerden, 1981). Baltimore, Duncan, Shapiro, and Edberg (1989) found as many as 85% of infants to carry AGNB during their first year of life. This figure however, reduces with age. Hable, Washington, and Herrmann (1971), who studied 490 children under the age of 16, found the carriage of AGNB to be less than 5%.

Selective Decontamination

Selective decontamination of the digestive tract (SDD) is a prophylactic procedure in which topically applied, non-absorbable anti-microbials are used to eradicate aerobic gram-negative microorganisms (AGNB) from the gastrointestinal tract. The term *selective* is used because the anti-microbials that are administered do not affect the normal largely anaerobic flora of the gastrointestinal tract, but selectively destroy AGNB.

Selective decontamination in its full form has four components which are required to be carried out simultaneously:

1. The application of non-absorbable anti-microbials suspended in a paste or gel to the mucous membranes of the oropharynx (in addition, instillation of a suspension of the same anti-microbial directly into the gut via a nasogastric tube);
2. A systemic antibiotic administered intravenously for 3 to 4 days after admission to hospital to prevent early infections that may develop before decontamination is achieved;
3. Surveillance swabs from throat and rectum to ascertain which microorganisms are carried by the patient on admission to hospital and at a later stage to monitor the affects of SDD on the gut flora; and
4. A high standard of oral hygiene and adherence to infection control procedures are necessary to prevent cross-infection from occurring.

Selective decontamination has been previously used in a diverse group of patients with varying degrees of success. Most data have arisen from the management of patients in the Intensive Care Unit (ICU) with both medical and post surgical problems.

The majority of clinical trials of SDD have been performed with ICU patients who are intubated and mechanically ventilated. Unfortunately, endotracheal intubation provides a ready access for pathogenic microorganisms to enter the respiratory tract. Over 30 trials have been published, the majority of which show that SDD is capable of eradicating AGNB from the gastrointestinal tract. SDD may also reduce the number of deaths amongst ICU patients (Ledingham et al., 1988; Ulrick et al., 1989). While the morbidity and mortality may be reduced, the cost of SDD may unfortunately increase the overall cost of care in the ICU setting (Hammond, 1993).

The admission of multiple trauma patients to the ICU shows how comparatively normal oral flora can be rapidly altered in a previously fit and healthy individual. Selective decontamination has been used in patients with cirrhosis, those undergoing liver transplantation, and those with end stage liver failure. It is known that liver transplant patients have an increased risk of post-operative infection with rates often exceeding 50% (Arnow, Carandang, Zabner, & Irwin, 1996). In their study, Arnow and colleagues found that SDD did not reduce infections, but did cause problems due to gastrointestinal intolerance and poor compliance. It must, however, be noted that, as donor organs often only become available at short notice, SDD was not started as early as one might have considered to be advantageous.

SDD in Stroke

Millns, Gosney, Jack, Martin, and Wright (2003) have shown that oral Gram-negative bacilli are often found immediately following an acute stroke. Both isolation and colonization are identified and the organisms are essentially AGNB. As a result of this study and others, both in the acute and rehabilitation setting (Gosney, Millns, Martin, & Field, 1997), the role of selective decontamination following an acute stroke was investigated. We recruited stroke patients who were acutely, but not critically, ill and carried out a prospective, randomized, double-blind placebo-controlled clinical trial in the acute stoke assessment unit of three hospitals in the United Kingdom. Our selected decontamination regime included 2% (w/v) colistin, 2% (w/v) polymixin, and 2% (w/v) amphotericin B. This gel was applied four times a day for either 2 or 3 weeks, depending on the presence of a normal or abnormal swallow on admission. We monitored the microorganisms that were present in the oral cavity of all subjects on nine separate occasions, taking swabs at least three times per week. There has been no previous study looking at the role of SDD in the management of acute stroke patients. In our study of 200 patients, we found a total of 125 AGNB to be isolated from 48 patients. The organisms isolated most commonly were Escherichia coli, Serratia marcescens, Entero-bacter aerogenes and Enterobacter sakazaki. In patients who received the SDD, there were fewer episodes of pneumonia that were diagnosed both clinically and radiologically (Gosney, Martin, & Wright, in press).

Stroke continues to be a depressingly familiar clinical syndrome. Dysphagia occurs, albeit transiently, in a large number of patients following an acute stroke. Evidence suggests that the oral flora are affected by stroke, and studies of patients with and without dysphagia indicate that micro-aspiration may be occurring. The oral cavity is colonized by many organisms, including AGNB, which may result in micro-aspiration and subsequent aspiration pneumonia. While SDD is a new procedure in acute stroke, it is well documented to reduce morbidity and mortality in other settings. Early evidence suggests that SDD may be advantageous in the management of acute stroke patients at risk of aspiration pneumonia.

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Continuing Education Questions

1. Which of the following is not a clinical feature suggesting an increased risk of aspiration?
   a. Abnormal gag reflex
   b. Cough after swallow
   c. Dysphonia
   d. Dysarthria
   e. Aphasia

2. The following investigation is most likely to detect micro-aspiration following a stroke?
   a. Water swallow test
   b. Tracheal pH test
   c. Examination of the vocal cords
   d. Videofluoroscopy
   e. Chest radiograph

3. Which of the following is a clinical feature associated with swallowing in a patient with dysphagia following a stroke?
   a. Rapid swallowing
   b. Smaller volume of saliva per swallow
   c. Large volume of saliva
   d. Drooling
   e. Dry mouth

4. In patients with stroke, the aspirated material considered most important in causation of pneumonia is
   a. water.
   b. gastric contents.
   c. saliva.
   d. solid food material.
   e. liquids with high pH levels.

5. The most common abnormality detected in swallowing following a stroke is
   a. poor tongue control.
   b. facial nerve paralysis.
   c. delayed swallow.
   d. reduced salivary flow.
   e. reduced peristalsis.