

Dra. Andrea Jobe

Executive Director and Director of Speech Programs / RSF-EARTHSPEAK

REHABILITATION IN PATIENTS WITH CLEFT PALATE SPEECH

Three Major Factors in the Rehabilitation of Cleft Palate Speech

The rehabilitation of cleft palate speech ideally requires an integrated, team approach incorporating the professional efforts of:

- plastic and reconstructive surgery
- speech and language pathology
- dentistry and orthodontia

The impact a cleft palate has upon speech production cannot be overstated. A number of the major organs of speech have interrupted function due to this deformity. Even with surgical correction, speech may not proceed normally without therapeutic help.

If surgical correction of the cleft lip and/or palate is done before 1 year of age, there is a good likelihood that speech development will be normal. However, if such correction occurs after 1 year of age or the age of speech onset, a significant number of children may still require speech therapy in order to overcome their incorrect method of sound production. Even with children who have had cleft lip and palate repair before the onset of speech, as many as 25% of them may have the need for some speech therapy

Historically, such correction has been problematic in developing nations. There are many reasons for this: economic, geographical and availability of speech therapy services. The conventional methods of speech therapy require that an individual be

brought to the professional's office 2 to 3 times a week for individual or group lessons that can last up to 1 hour. The fee can be high for such service where it is available. Poor teeth alignment or missing teeth due to complete cleft lip and palate can also contribute to the speech problem

For the past 18 years, a method to provide speech correction for cleft palate speech to patients who have no access to speech therapy has been sought by the individuals of RSF-EARTHSPEAK. Exploration of ways that dental and orthodontic assistance can be brought to these individuals is also being done.

Over the years a method called **Corrective Babbling** has been developed. This method is delivered through educating parents and caregivers to become the speech teachers their children need. This bypasses the geographical, economic and availability barriers that currently exist. Corrective Babbling is a scientifically based approach that uses what we know about the organs of speech, speech sound production, developmental stages of speech learning, speech teaching and how the problems of cleft lip and palate challenge normal speech development.

How Speech is effected by a Cleft Palate

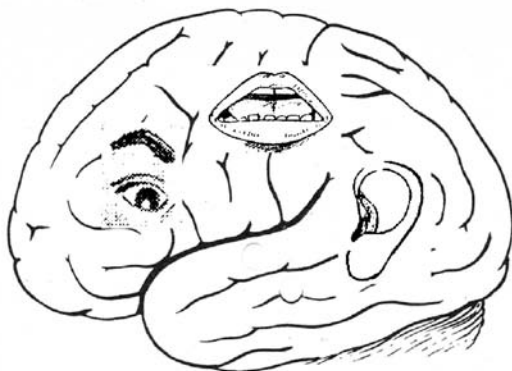
There are no special organs devoted to speech in mankind. Organs that are used for respiration and eating are adapted for speech use.

Shortly after birth, children begin to use the organs of respiration and eating to learn the speech sounds of their native language. This process begins at birth with the first cry, proceeds through stages of “cooing” and proceeds on to babbling.

Crying begins the development of oral and nasal airflow distinction. Cooing forms the motor basis for learning the vowel sounds and babbling teaches the consonants and vowel combinations that later form words. This development proceeds and intensifies until the child is about 1 year of age. At this time, the stored sound-motor patterns will then be further refined and employed in word development as expressive language begins.

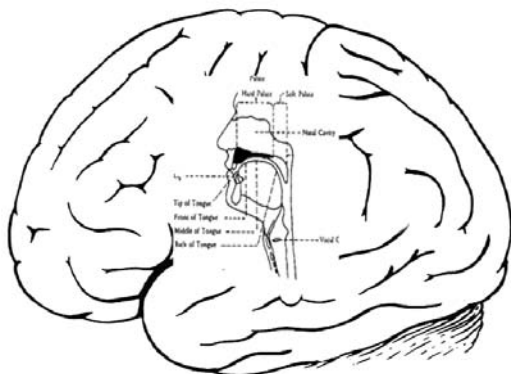
The developing child first learns the sounds of his native language by observing sounds that he sees, feels and hears. He is constantly bathed in an environment of these sounds as his mother and others “talk” to him

This cycle, external reinforcement and storage is what permits us to habituate sounds and make them readily available to use when we begin speaking.



Child— Sees Feels Hear
About 4 months of age the developing child begins to try to imitate the sounds that he has seen, felt and heard using his own organs of speech.

Child— Imitates what is seen, felt and heard



The mother and other speakers of the child's language reinforce this constant cycle of practice until he builds a stored sound-motor-pattern in his brain for each sound of his native language. It is these stored sound-motor patterns that will later be used in different syllable combinations to make up the words of the child's language.

Child— sees a “cat” and says cat

With or without a cleft palate this process occurs normally in all children and is essential to speech development

Children with unrepaired cleft palates during this vital speech learning time will engage in this cycle as well. However, these children are handicapped by the inability to feel the sounds they see and hear or to reproduce them with intact organs of speech. This in turn leads to the habituated storage of incorrect sound motor patterns for each speech sound.

Each sound has 4 characteristic features that make it different from each other sound. These features are created by using the organs of speech in different combinations. Each sound has its own sound-motor pattern just like a musical note.

The 4 features of each sound are:

- **Place** (where in the oral or nasal cavity the sound is made)
- **Manner** (what the organs of speech do to the air flow coming from the lungs)
- **Air Direction** (whether the air exits from the nose or mouth)
- **Voicing** (whether the vocal cords vibrate or not)

Lacking an intact hard and/or soft palate, the child with a cleft will be unable to create some of these features or combine them in a conventional way. He will adopt incorrect ways of making each sound in his attempts to override the open palate.

This results in cleft palate speech. Speech that contains incorrect sound-motor patterns and speech that is firmly habituated and resistant to change even after surgical correction of the origin of the problem has been done.

Effective speech therapy is needed to change this problem. RSF-EARTHSPEAK teams are working as volunteers in developing nations to teach parents and others about the nature of the cleft palate speech problem and how to correct it. Speech seminars and weeklong speech camps to train parents in the Corrective Babbling approach are held. This approach is meeting with success and can be an effective tool in helping overcome the speech deficits of children born with cleft palate.

Dr. Debra Johnson

*Chief of Surgery for the Sutter Community Hospitals,
and Co-Director of the Sutter Cleft Lip and Palate Panel.
Member of the Board of Directors for Interplast, Inc.*

THE GENETICS OF CLEFT LIP AND PALATE

Clefts occur in approximately 1:700 births.

- 1:750 births in Caucasians
- 1:500 births in Asians
- 1:1200 in Africans

Clefts can occur as cleft lip alone, cleft lip/palate, or cleft palate alone

- Cleft lip alone: 21% of clefts
- Cleft lip/palate together: 46% of clefts
- Cleft palate alone: 33% of clefts
- Bilateral cleft lip is associated with a cleft palate in 86% of cases

Clefts occur in boys more commonly than in girls

Ratio of cleft lip: left 6:right 3: bilateral 1

Causes of clefting:

For most, no single factor can be identified as the cause.

Isolated clefts are those that have no other birth anomaly.

Syndromic clefts are those associated with other birth disorders.

Clefts are a feature of over 300 Syndromes, and most are rare.

More common syndromes: Pierre-Robin sequence, Crouzon,

Apert, Pfeiffer, Van der Woude, Treacher Collins,
Velocardiofacial

Syndromal clefts make up 15% of cleft lip +/- palate
50% of isolated cleft palate
75% of VPI are syndromic

Isolated clefts: caused by an interaction between an individual's genes and certain environmental factors (often impossible to identify). Phenytoin, Accutane, alcohol, tobacco, folic acid and pyridoxine deficiencies have been associated with clefting. Increasing parental age, especially an older father, is associated. About 35% of clefts have a positive family history.

Human Genome Project: identifying genes related to clefting. Genes related to the production of tissue growth factor alpha, and fibroblast growth factor receptors have shown an association with clefts.

Genetic testing may soon allow us to predict those families that may have a higher risk of cleft babies, although, as Dr. Millard says, “There is little chance that the molecular geneticist will arrive in an operating room with a cleft repair gene attached to a retrovirus anytime soon.”

What are the risks that another family member will be born with a cleft?

For parents of one cleft child: **2-5% risk** of a second child with a cleft

If additional family members have clefts: **10-12% risk**

For a person born with a cleft: **2-5% risk** of having a cleft child

If additional family members have clefts: **10-12% risk**

For siblings of a person with a cleft: **1% risk**

If additional family members have clefts: **5-6% risk**

If a **syndrome** is involved: risk can be as high as 50%. These patients should have a genetic evaluation.

Cleft lip and/or palate implies a risk of recurrence that ranges from incomplete CL alone to bilateral CL and P.

Cleft palate alone implies a risk for cleft palate only; these families are not at risk for cleft lip.

Genetic Evaluation:

Obtain a detailed family history, a medical history, and physical examination of the cleft patient, and laboratory testing.

1. Verify that the cleft is “isolated” and not part of a syndrome.
2. Evaluate whether other relatives have similar conditions, and how closely related they are. The greater the number of relatives known to have clefts, and the closer their biologic relation, the greater the risk of recurrence.
3. Consider the type and severity of the cleft. Clefts tend to be consistent within families, although severity can vary.
4. Testing: chromosomal testing if a syndrome is suspected; radiographs; molecular testing is available for some specific conditions; photographs.
5. **Counseling:** discussion of treatment necessary; risk of recurrence; discussion of strategies for future prenatal diagnosis.

Donald R. Laub, M.D., FACS

*Adjunct Clinical Associate Professor of Surgery,
Stanford Medical School Founder, Interplast*

Welcome

You are reading a manual on helping the cleft patient. This work is the most noble and most important and most effective work of mankind. You don't require to be congratulated. Because you are—

Professional person

A professional person; each one of you is a professional person, that is a person who has devoted his or her life to a skill and a science, and you practice that skill for the good of the **other** person. This act produces a very comfortable feeling—immediate gratification if you will—when you have helped someone with a severe deformity and significantly changed their fortunes for the rest of their lives.

Psychic Income

This is the **Psychic Income**. A professional person does the work for the good of the other person, which is in contrast to the non-professional person who performs his skill for the good of himself primarily. For example, the infamous CEOs of large corporations.

This **Psychic Income** is so powerful that it possibly produces a chemical affecting the brain that addicts us to do this type of work. Psychic Income is the **motor** which runs all Plastic Surgery Voluntary Foundations, and it is the motor for CPM (Cirujanos Plasticos Mundi), and it is what makes the world go around as far as the Plastic Surgery organizations designed to help the developing world are concerned.

For example, the founders of most plastic surgery helping foundations and most of the foundations devoted to orthodontia, speech therapy, ENT, dentistry, to help the cleft child, both the founders and the members, relate a similar personal experience on the occasion of taking care of the first child they have had the privilege of helping with their skill. Many or most of these people relate that at the moment of receiving

this special **psychic income** that it caused a change in their value system to be more humanitarian. In a way it was **the child that helped the professional**, to change their life to be more humanitarian.

It is as if the “tail is now wagging the dog”, the tail being the Psychic Income and the Dog being the Physician and the paramedical person, who receives impetus to do this type of work or to form to a professional foundation. Here the patient becomes the one who produces the result in the surgeon. This phenomenon of the Doctor **needing** the patient reverses or erases our preoperative mind set that the surgeon is the almighty one and the patient is entirely a recipient of the surgeon’s skill and benevolence.

We are all on a horizontal relationship: doctor + patient both, not a vertical relationship

The team of a foundation must also consist of businessmen, accountants, lawyers and fundraisers; and all of these are vital to our life.

In this instance, people with these skills are also professionals because they are working for the other person and they derive the same Psychic Income as the physicians do, because they are acting as surrogate surgeons or surrogate medical professionals. After all, it is because of these surrogate physician professionals that all of this is made possible.

When these two types of skills work together, we form a **new** way of practicing medicine. It is in these foundations where there is a true teamwork, where medicine and business **truly work together** for the patients benefit **and** for each other’s betterment of their individual specialty.

A true combination of business and medicine is produced by the commonality of humanitarianism.

In this case, one + one equals three: it is obvious that medicine and business working together is a very powerful unit.

All of the elements in this process evolved at many places simultaneously. My experience is for example at Stanford where, as at the other places, it was recognized that the needs of the students and the **residents in training** would be better solved in the setting of these programs. The acquisition of the psychomotor or surgical skills by trainees in these programs was excellent. This method of teaching is second to no other method. The residents who were there for the reason of learning the clinical or surgical parts of this process were delighted with what was going on;

they were learning what is or was the very epitome of the field: the cleft lip repair and the cleft palate repair, and the nasal reconstruction for the cleft: for them this was the highest achievement toward their goal of learning surgery.

Peak Experience

As they learned skills, they were sort of in a state of ecstasy because this constitutes a **peak experience** for the trainee.

Value Change

A **Peak Experience** occurs at birth, when we are married, or are divorced, or graduate, or receive an award—or **perform our first cleft lip repair**. At the time of a peak experience, our value system can change. For example, at the conclusion of this landmark operation for them, they might say, “This was the best experience I have ever had in my life; I want to do this for the rest of my life.” At that moment in the training stage, the imprinting is apt to be much more permanent, meaningful, long-lasting, and appropriate, than if these values of **humanitarianism** are transferred or acquired at a post-residency level. This process easily occurs for all practicing physicians and surgeons at any point in their careers; and it happened to me in early residency, and I assume it occurs for you at every cleft surgery. The imprinting is best done at the time in our careers set aside for learning “to the max”, which is residency or fellowship training.

When the trainee states, “I want to do this for the rest of my life,” she or he has indicated that an attitude has been transferred to that “student” as well as a skill. Because the operation causing such psychic income was on a child where no fee was charged, this was a humanitarian act, so in this way the attitude of helping others was also transferred and imprinted. And I have heard, on 40 occasions, those words—at the end of the 1st cleft lip repair (repeat), “This was the best experience I have had in my life, I want to do this for the rest of my life,” a value change had occurred, and the skill and the social **attitude** became part of that person’s life from that time of the peak experience on.

In Dr. Richard Jobe’s survey of the practicing surgeons who had undergone these experiences, as a resident, plus or minus 35% had continued practicing this work, and had retained this value.

Interdisciplinary contact is necessary

The patient changed the surgeon in a profound way; the “tail wagged the dog”; a good outcome resulted.

Now turning to another aspect of our professional life, let me discuss the danger of a few in a University who achieve great excellence in a small field, and achieve power and notoriety within their system. The tendency to pout and cry may occur if each of your objectives is not immediately met by the Dean or the ruling class or your peers. The tendency is to say, “I quit, and I will form my own institute in order that I can practice excellence.”

What happens in this case is that interdisciplinary contact is eliminated. The cross-fertilization from different methods of thinking and from different related fields is eliminated. It's probably more difficult to form multi-disciplinary efforts with equal emphasis given to all of the “ancillary” fields when your practice is with an institute without pluralism, even though the institute is seemingly the ideal setting.

The advancements in that particular field may then wither.

The multidisciplinary approach has helped develop certain fields of surgery:

MULTIDISCIPLINARY INITIATIVES THAT HAVE WORKED:

- Plastic Surgery
- Cleft Surgery and Humanitarian Surgery
- Cosmetic Surgery
- Maxillofacial Surgery (both cosmetic and reconstructive).
- Surgery for Craniofacial anomalies
- Hand Surgery
- Skin Physiology and aesthetic improvement based in this science
- Microsurgery itself
- Joint replacement Surgery
- Neurosurgery for Epilepsy
- Microsurgery including tissue tolerance and limb transplantation.
- Bariatric Microsurgery
- Ophthalmic surgery for retinal disease and for nearsighted patients.
- Oncologic Surgery

AREAS THAT HAVE NOT BENEFITED AS MUCH FROM THE MULTIDISCIPLINARY INITIATIVES:

- Breast Surgery
- Parts of Oncologic Surgery

The theory behind Residents on Trips

And in the future, the equilibrium between oral surgery and ENT and plastic surgery will require the skill and diplomacy that only occurs in a University environment and does not occur in an institute.

Hijo de tigre nacio pintado. The nourishment of our young, our own progeny in each of our “narrow” fields is important, and is on a par with the importance of the multidisciplinary effort.

No doubt about it, the Teaching of the Residents in developed countries is as vital as teaching in other lands, because if the young (students and residents and impressionable youngsters) are not nurtured and induced to gain the excitement and pleasure of Psychic Income, the field will not reproduce itself. Withholding this process is similar to practicing birth control on your own professional discipline.

Advances in development of our fields

If the professionals do not teach in this way, they are sterilizing themselves. They prevent reproduction their own kind.

Furthermore, medicine is not a static science, new operations and new advances are occurring at regular intervals.

The inclusion of our residents in intense training experiences is a link in the chain, which advances our field.

For example, in cleft lip and palate surgery, think of what should happen in the five years from now, and also think what will not happen in five years if you do not bring in new brains and new skills?

For example:

Intrauterine fetal surgery will not be developed to repair cleft lip.

New operations will not have been developed, e.g., Mike Carsten's (a resident) embryologic concept of moving the bone and the soft tissue as one neurovascular unit to repair cleft lip and craniofacial anomalies.¹

The Most Important Thing

Enthusing young people to enter our field is clearly vital to ourselves and to the patients, who are **the most important thing**.

Repeat, Humanitarianism should be taught at the age when teaching is done, is best done, is most effective.

“Enlightened self-interest”

In the greater perspective, we can consider the effect of our work on our world, which will occur only through our children, and our residents. Our children and our residents will be needed in the formation of public opinion in the next few years. Just think how the world would change if our governments and our corporations and our politicians were to regard this way of life as a thing of value. If our very own children felt that helping others in these ways were **a thing of value** they might counter-balance their conditioning toward their aspirations to acquire the latest clothing styles, the latest entertainment, and their latest idea about what they should acquire in life.

But both aspirations seem necessary.

Governments might divert a small billion or two toward these projects for their own good. Their own political projects would enjoy easier success. They would gain favor in the foreign countries and gain votes here in the developed world.

Our corporations could actually make more money by being nice to people in foreign countries. This concept might mature into more than “enlightened self-interest” (a phrase taken from history), but into a sincere value change.

A value change would increase the spirit of the employees in the large corporation;

¹ Carsten has shown that Clefting occurs when one neurovascular unit of bone and soft tissue unit become deficient during fetal development and that the repair of cleft should be based on this concept.

their company newspaper would tout the companies' social conscience to the pride and delight of their more socially conscious employees, would raise the profits of the company and their "host" country; perhaps the actual expressed goals for the corporation would perhaps include the **good of the employees**; the shareholders and officers might see it this way, and all countries would benefit. This mindset is not really "thinking different" or O.O.T.B.², but it is thinking in the longer term in an educated way, a bit more professional way.

This thing of value should be regarded as equal to the tangible income of making money and parlaying that money into more money.

The field moves forward.

Speaking of a modern, more educated method of "developing the field" of Plastic and Reconstructive Surgery: both in regard to the educational process and even the research, the innovative progression should include:

Developed
&
Developing } Country Professionals working together.

In effect, we almost double the amount of brainpower brought into use by increasing exchange of ideas between disciplines and between countries by sharing research at an earlier level, and by assuming commonality of purpose.

This new concept leads to **virtual centers of excellence** because some professionals may be geographically separated but united by a web-based center of excellence (See Dingman PRS 2002). Again, to repeat, we are securing the development of new operations, of research, and of **new surgeons**. We see the development of multidisciplinary affiliated disciplines in both countries.

Example of personal "Modern" History of theories discussed

Consider some Stanford medical initiatives.

² Out Of The Box

Multidisciplinary humanitarianism, and Residents on trips

In 1963 at Stanford, Dr. Chase, my mentor and professional father, began our program with:

- a) Skill
- b) The other person in mind.

This combination led to the performing of a free surgery on a single patient, Antonio Victoria from Mexicali, Mexico and then later this led to the formation of Mexico Medical Project, Inc. and subsequently *Interplast*. Our first initiatives used for teaching, for obtaining patients with advanced pathology in our new hospital system, are examples of being **committed to a goal**. They were as follows:

When challenged by the official opinion of the Mexican Government to not return to their fair country for further surgical work on children with developmental deformities, and adults with acquired deformity (burns, hand injuries, tumors), we pouted for only a short time. And then for some unknown reason conceived a “Plan B” for that situation. The government of Mexico had not initiated a more intense program to help their own citizens. At that relatively naïve time for us we “collaged” our assets (our group had 5 assets interlocking goals): Reconstructive Surgery Training, a knowledge of ships and the sea, a leadership experience with the U.S. Navy, an idealist in the law enforcement department of Los Altos, California, a veteran with personal experience in pre-juvenile delinquency rehab., a University faculty position, and a Rockefeller Foundation connection.

We identified yard freighter 879 in the San Diego Reserve (Mothball) fleet and then, a Culinary Instructor, and also a retired Navy Captain for command, policemen to refer 14 year-old pre-juvenile delinquents for rehabilitation, a medical corpsman instructor, teaching faculties, textbooks (Lange Medical Synopses), David Werner’s paramedical volume, and a retired Naval electronics Veteran, and educators in seamanship. The yard freighter has 35 feet of clear room with no internal cross member supports to allow an operating room, a post-op care unit, preparation room and a supply place. Quarters for the patients and crew were above deck. A lounge was to be identified. The kitchen was new, never used. The ship had been built in Philadelphia and towed to San Diego at the end of the war; it was kept air aconditioned for 25 years and maintained perfectly.

It drew only 3 ft of water and was ready for work in the shallow harbors of Western Mexico and South America. We visited the pentagon and arranged for the ship to be released at a certain moment, at which time we were to have our application on

Capt. Banan's desk. Any University has second priority to military material declared surplus. Dean John Wilson asked his nice friend at Rockefeller Foundation to arrange a grant for the project based on U.S. Navy experience and the experience gained.

In Norway, where socially deviant persons learned self-worth, ability to not be self-centered, and the necessity to work together as a team when working onboard a ship. Their programs resulted in less recidivism (back to jail or to the "Brig.").

Using the yard freighter in the San Diego Reserve Fleet, we had a method to train pre-juvenal delinquents in

- a) Culinary arts
- b) Electronic skills
- c) Seamanship
- d) Medical corpsman

Our second abortive attempt to do the type of work we are addressing in this symposium was the DC-3 airplane. The DC-3 was purchased by *Interplast* as safe and inexpensive transportation. It increased esprit du corps, higher and higher, until an unscheduled landing occurred, which of course led to another plan, to the formation of an *Interplast* "air force", consisting of volunteer pilots and their airplanes, for transportation to nearby countries. It was another multidisciplinary initiative "assured" of success. These aircraft were used for transportation to clinics and hospitals in other countries, including parts of the U.S. The plan was inexpensive, running at 1/2 cost of commercial transport.

Innovative funding from the community

Initial funds were derived from:

San Mateo Chope Hospital Surgical Medical funds

Gender Surgery Fees

Clair Elgin (a patient with the worst diagnosis and deformity who had "struck it rich" with her invention).

Our initial PRS patients were derived from:

Physiatry Department (paraplegic and quadriplegic)

Jail (Lombroso's Theory that improving appearance improves social behavior)

Menlo Park Veteran's Administration Psychiatric Hospital (2,000 patients, many with skin cancer, Carpal Tunnel Syndrome, or Visual Field Defects, i.e. need for large scale blepharoplasty)

And of course, *Interplast*—actually, Interplast was part of the educational process emanating from Stanford to provide pathology for residents and students.

Success

This initiative over the years lead to 2,000 patient surgeries from Mexicali, 4,000 patients and surgeries from San Pedro Sula, Honduras, 50,000 patients total from various countries and 40,000 patients from developing countries for Interplast Germany.

Dear colleagues—the personal example of commitment to Plastic Surgery and a multidisciplinary effort for those in need is related to you not for what sounds like self-interest, but I write it to you so that we might share the commonality of our humanitarian efforts, all of which are both personal and also in the name of all of us.

“Even if we are occupied with most important things, even if we attain to high honor, or fall into great misfortune, still, let us remember how good it was once here when we were all together united by a good and kind feeling which made us... better, perhaps than we are.”

-Fyodor Dostoevsky, *The Brothers Karamazov*

Upwards and Onwards.

The child with a difficult airway

Pedro Charco Mora, MD.
Critical Care Anesthesiology.
Hospital Universitario Son Dureta, Palma de Mallorca, Spain.
Vicente Martinez Pons, MD.
Critical Care Anesthesiology.
Hospital Univ. F. Borja, Gandia, Spain.
Valentin Madrid Rondon, MD.
Critical Care Anesthesiology.
Hospital Univ. Marina Alta, Denia, Spain.

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1 Introduction:

One of the most challenging events in the practice of anaesthesia is the management of the paediatric patient with a difficult airway. Neonates, infants and children display a wide spectrum of diseases that may present at any time to the hospital with airway problems. Hence, anaesthesiologists that participate in the management of the paediatric patient should have a thorough and detailed plan on how to recognize and treat these patients.

Studies have shown that the paediatric patient has a higher risk of significant morbidity and mortality during anaesthesia when compared to the adult patient.¹ Also, in a review of closed claims studies, Morray, et al, reported that respiratory events are the major reason for morbidity and mortality in the perioperative period.² In addition, they represent the primary cause of poor outcome.² Complete familiarity with the characteristic features of airway anatomy and physiology in the paediatric patient has been found to decrease this incidence of adverse events.³

2 Pediatric and adult airway differences:

There are significant differences between the paediatric and adult airways (Table 1)⁴ The anatomic features include differences in both size, shape and position of the airway as well as in the airway epithelium and its supporting structures. Physiologic differences between the neonatal and adult respiratory systems arise from these anatomic differences and from mechanisms in respiratory control.

A. Upper Airway

The upper airway of the newborn infant is smaller and anatomically different than the adult. The tongue is relatively large and occupies fully the cavity of the mouth and oropharynx. Most, but not all neonates are also obligate nasal breathers because the epiglottis, positioned high in the pharynx, almost meets the soft palate, making oral ventilation difficult.⁵ This lasts from 2 to 6 months of age. Unlike older infants and children, neonates have almost no lymphoid tissue in the upper airway. The tonsils and adenoids appear during the second year of life and generally reach their largest size by 4 to 7 years of age, after which they gradually recede in the absence of intervening infections.

The larynx is located at a high position. In the baby, the body of the hyoid bone is situated approximately at the level of the disc between the third and fourth cervical vertebrae.⁶ As the infant grows, the glottis moves caudally to a C5 to C6 vertebral level by maturity. The high position of the epiglottis and larynx allows the

infant to breath and swallow simultaneously. Similarly, both the thyroid and cricoid cartilages move caudal as the thyrohyoid and cricothyroid membranes develop. The larynx also differs in several respects. The epiglottis is more U-shaped, and protrudes over the larynx at a 45° angle. Because the larynx of the infant is high and has an anterior inclination, the straight laryngoscope blade is most useful. The view can be markedly improved by external pressure on the larynx, pushing it backward. The larynx is funnel-shaped in children less than 8 to 10 years of age, with the narrowest portion being at the level of the cricoid ring.

In the adult, the narrowest portion of the airway is between the vocal cords.

Additionally, the vocal cords of the neonate are slanted such that the anterior commissure is more caudal than the posterior commissure. The tracheal direction in the infant is downward and posterior, whereas in the adult it is straight downward. Consequently, the application of cricoid pressure is more effective in an infant when placing an endotracheal tube. Also, in the newborn infant the distance between the bifurcation of the trachea and the vocal cords is 4 to 5cm. Thus an endotracheal tube must be very carefully positioned and fixed because the tip of the tube can move about 2cm during flexion or extension of the head.

Airflow in the upper airway is turbulent even during quiet respiration. Laminar flow begins at the level of the fourth or fifth bronchial divisions, where the rapid increase in crosssection area decreases airflow velocity. The resistance to turbulent gas flow is proportioned to the fifth power of the radius of the airway. Subsequently, 1mm of edema in the trachea of the newborn (which reduces the radius from 2.1 to 1.1mm) increases the resistance to air flow approximately 25-fold.

In general, the right main bronchus is less angled than the left. Hence the right main bronchus is the one most frequently intubated during endobronchial intubation, and foreign bodies tend to lodge in the right side more frequently.

B. Lower Airway

At the fetal stage the pattern of the bronchial tree is fully developed by the 16th week of gestation. Alveoli develop later and increase in number until 8 years of age and in size until full development of the chest wall. The lining of the respiratory sacules and alveoli is derived from two types of cells: Type I pneumocytes produce the lining supporting cells of the alveoli and contribute to the blood gas barrier. Type II pneumocytes are more glandular and contain inclusion cytoplasmic osmiophilic granules. Pulmonary surfactant is synthesized in these granular pneumocytes (Type II) and is stored in the lamellar bodies. It is released by fusion of the lamellar body membrane with the cell wall.

The highly compliant chest wall in neonates and infants increases the work of

breathing. This greater compliance is attributable to their softer, noncalcified ribs, which articulate with the vertebral column and sternum at right angles. The adult's more rigid chest wall articulates at downsloping angles with a more efficient chest wall excursion. The diaphragm is therefore, more important and is the mainstay of ventilation in the infant. However, it also has some disadvantages. It has proportionally fewer Type I fast oxidative muscle fibers than the diaphragms of children older than 2 years. So, the mechanism of contraction is less efficient and the muscle tires faster.

C. Respiratory Function

When anesthetizing infants and small children, it is important to realize their physiologic disadvantages when compared to older children or adults. The infant has a higher metabolic rate with increased oxygen consumption. Thus, they have less oxygen reserve and can become hypoxic much faster than the adult. Functional residual capacity (FRC) is also decreased to a greater extent in infants by general anaesthesia. The two main differences are in respiratory rate and alveolar ventilation. This is understandable due to their higher metabolic rate and oxygen consumption.

Mask ventilation in infants and children can rapidly lead to gastric distension. This can decrease FRC, elevate the diaphragm, decrease lung compliance, and increase the risk of aspiration.

Infants and small children may have an increased sensitivity of certain inspiratory muscles to anaesthetic agents.⁷ This may lead to an increased incidence of airway obstruction.

3 Airway Equipment for Managing the Paediatric Airway:

Successful management of the infant or child with a difficult airway requires having the appropriate equipment.

Nearly everything that is available for use in adults is now available for children, obviously, reduced in size. Appropriate face masks, oropharyngeal airways, nasopharyngeal airways, endotracheal tubes, stylets and laryngoscope blades should be available. This section of the chapter though will concentrate on newer forms of equipment that have helped immensely in the management of the difficult paediatric airway (Table 2). A detailed description is beyond the scope of this article. The reader is referred to the references.

A. Laryngeal Mask Airway (LMA)

The LMA was first described in adults by Dr. Brain in 1983.⁸

Its use in children has also been described.⁹ It is available in sizes 1,2,2.5, and 3 for use in paediatric patients. It may be used as the sole airway of choice to ventilate the lungs when endotracheal intubation or mask ventilation is undesirable or difficult. It may also be used to facilitate either a blind or fiberoptic intubation of the trachea. The LMA has now become part of the sequence for difficult or failed intubation in both adults and children.¹⁰

The second generation LMA or Fastrack is not available in small sizes. It can be used, though, in older children. Its advantage is the fact that a blind intubation is easier to obtain with the Fastrack.

The third generation LMA or Proseal is available for children over 5 kilograms.¹¹ It has an inner tube to aspirate stomach contents, thus making aspiration a rare occurrence.

B. Flexible Fiberoptic Bronchoscope (FFB)

The FFB has been in use for many years although only recently has it gained widespread use in children.¹³ The primary use for anesthesiologists is in the assistance of endotracheal intubation. The fiberscopes most commonly used in paediatrics vary in external diameters from 2.2mm (capable of passing through a 2.5mm ET) to 4.0mm (capable of passing through a 4.5mm ET). The 2.2mm "ultrathin" scope has a flexible tip but lacks a suction port.

Successful use of the fiberoptic scope as a tool to intubate the trachea in infants and children depends on several factors.

Infants and children generally do not cooperate during awake fiberoptic intubation. It is generally easier to keep the infant or child anesthetized but breathing spontaneously on 100% oxygen and an inhalational agent such as sevoflurane. This can be accomplished with the use of a nasal cannula or a nasal endotracheal tube placed blindly at the inlet of the airway, or more recently, with the use of the endoscopy mask.¹² The endoscopy mask allows simultaneous anaesthesia and ventilation of the patient during fiberoptic intubation or diagnostic airway endoscopy. It is available in three different sizes for infants, children and adults.

C. Bullard Laryngoscope

This laryngoscope is available in both a paediatric and an adult size. It is a particular blade equipped with fiberoptic and mirror technology to allow indirect visualization of the larynx with minimal mouth opening and neck motion. It does not require the alignment of the oral, pharyngeal, and laryngeal axes. The pediatric version is

characterized by a blade that is narrower and a terminal angulation that is more acute than the adult version. The trachea is intubated by advancing an endotracheal tube that was previously loaded on to the device's intubating stylet, which fastens to the right side of the laryngoscope.

The Bullard laryngoscope has been used with good success in the management of the difficult airway in children.¹⁴

D. Lightwand

The lightwand utilizes the technique of transtracheal illumination for the blind intubation of the trachea. It has been demonstrated very useful in the management of difficult airways in children.¹⁵ A preselected endotracheal tube and the stylet is introduced into the trachea by visualizing the intensity of light visible on the anterior neck. Lightwands are inexpensive tools which can be used frequently, and are useful for both normal and abnormal airways. The technique is easy to learn and can be used in both anesthetized patients or in awake patients with proper sedation and topicalization of the airway.

Blood and secretions are not an impediment to success like in the fiberoptic bronchoscope. Recent developments have made the newer lightwand thin enough to use with endotracheal tubes as small as 2.5mm.

E. Shikani Seeing Optical Stylet (SOS)

The SOS is a recently introduced reusable intubating stylet produced in adult and paediatric versions.¹⁶ It combines features of a fiberoptic bronchoscope and a lightwand. The paediatric version is optimized for endotracheal tubes in the 3.0mm to 5.0mm I.D. size range.

F. Angulated Video-Intubation Laryngoscope (AVIL)

The AVIL is a MacIntosh laryngoscope that has been modified with a guide bore hole, leading from the bottom of the handle through the lateral flange of the blade to the blade tip.¹⁷ An ultrathin video-endoscope is inserted in the bore hole. It transmits the view from the distal blade tip directly onto a video-display and also provides airway illumination.

The AVIL with the angulated distal blade tip resembles an activated McCoy blade. In contrast to the McCoy blade, which can improve direct glottic visualization, the AVIL has been particularly designed to give an improved glottic view on a video-monitor during difficult tracheal intubation.

4 Anesthesia considerations:

A. Assessment of the Airway

It is crucial that to successfully manage the child with a difficult airway, a thorough history and physical examination be performed. The worst nightmare is to be caught unprepared during the induction of anaesthesia in a difficult airway child.

The history should include a review of prior records and/or anaesthetics, emphasizing the airway management during that time.

The history should also elicit any information concerning congenital, traumatic, inflammatory or other acquired lesions. A specific attention should be placed on any congenital lesion present in the patient since it can also manifest with a difficult airway. Any history of prior obstruction or sleepapnea should be elicited (snoring, apnea, daytime somnolence).

The physical examination should focus on the following: size and shape of the head; gross features of the face; size and symmetry of the mandible; size of the tongue and shape of the palate; prominence of upper incisors; and range of motion in the jaw, head and neck.

Occasionally, besides a thorough history and physical examination, additional studies may help in identifying specific features of the airway: awake laryngoscopy, flow volume loops, radiologic imaging and magnetic resonance imaging.

B. Premedication

Should be individualized. The majority of children with a compromised airway should not be given sedation or narcotics due to the fact that this could result in the loss of muscular tone and in respiratory depression, worsening the obstruction.¹⁸ In some older children in which an awake intubation is contemplated, the judicious use of mild sedation may be attempted. Anticholinergic agents are good since they decrease the volume of secretions and also may protect against vagal responses during the manipulation of the airway. Atropine may be administered IM (0.02mg/kg) or IV (0.01mg/kg).

C. Induction

The two main anaesthetic problems in the child with a difficult airway are control of the airway and the intubation.

The techniques used for induction of anaesthesia vary according to the severity of the pathology in the airway and the degree of respiratory difficulty. Regardless of what technique is used, an alternate plan is needed in the event of failure to obtain an

airway initially. You could divide the patients in four categories which will dictate the appropriate method for induction and intubation.

1. Type I Patients

These patients present with a normal respiratory frequency, mild respiratory distress, normal oxygen saturation, an airway that externally looks normal and minimal or non-existent sternal retractions.

2. Type II Patients

These patients might have significant airway disease and moderate airway distress but have a "known" airway. They have had already procedures and the surgical and anaesthesia teams are familiar with them (the team knows what technique works the best). An example might be the child that presents with acute airway obstruction due to recurrent laryngeal papillomas.

Type I and II patients usually get an inhalation induction with either halothane or sevoflurane. Slowly, positive pressure (5-10cm H₂O) is applied. This serves to confirm the possibility of ventilating the patient and it could help decrease the obstruction caused by soft tissues. Once it is confirmed that you can ventilate the patient, a muscle relaxant may be given and intubation performed. Alternatively, and especially if the airway is not adequate, intubation may be attempted without muscle relaxants.

3. Type III Patients

These patients may or may not be in respiratory distress but on physical exam their anatomy is abnormal, i.e. micrognathia, macroglossia, severe palatofacial deformity, or tumors displacing the airway. This group also includes children with lesions in the lower airway or anterior mediastinal masses which would be difficult to manage after administering general anaesthesia and neuromuscular agents.

4. Type IV Patients

These patients present for the first time with significant obstruction of the airway. They show clear symptoms of airway distress, sternal retractions, low oxygen saturation and obvious signs of fatigue. Examples include aspiration of a foreign body, croup, and epiglottitis.

Type III and IV patients require special preparation in anticipation of a difficult direct laryngoscopy and intubation. The personnel and equipment to establish an immediate airway should be available including those for a

paediatric surgical airway. In some lesions and in older children, the intubation may be performed awake with sedation. Incremental doses of intravenous midazolam 0.05-0.1mg/kg may be used along with topicalization of the airway.

The great majority of children will require a general anaesthetic. We believe that these patients should be kept breathing spontaneously for two main reasons. First, the administration of a muscle relaxant may cause complete airway obstruction due to the loss of tone in the muscles of the tongue, and the larynx. This obstruction may not resolve with manual ventilation. Second, the patient breathing spontaneously might be a valuable guide to localize the glottis (bubbles during expiration). An inhalation induction is performed and once the patient is deeply anesthetized, intubation is attempted. If it is not successful, alternate techniques are used. These may include: a blind nasal, a laryngeal mask (LMA), Bullard laryngoscope, a lightwand, or a fiberoptic intubation. In the case of anterior mediastinal masses, the size and location of the tumor and the degree of cardiovascular compromise could necessitate the rapid initiation of cardiopulmonary bypass (femfem).

5 Clinical examples:

A. Acute epiglottitis

Epiglottitis or supraglottitis is primarily a bacterial infection of the epiglottis and supraglottic structures.¹⁹ The bacteria associated most commonly is *Haemophilus influenzae* type B, although group A streptococci can also cause it. Continued wide use of the *Haemophilus influenzae* (H-flu) vaccine has decreased the number of infections caused by *H. influenzae*. It can occur at any age, although it is most common in children 3 to 5 years old. The onset is sudden (within hours of a child developing a respiratory infection) and is accompanied by severe systemic illness with high fever and respiratory distress. Severe airway obstruction can develop rapidly. Manifestations of the disease include the five "d's": drooling, dysphagia, dysphonia, dyspnea, and dehydration. The patient assumes a sitting position leaning forward, because this improves airflow, and the patient can breath easier.

Laboratory work-up is consistent with a bacterial infection (leukocytosis). Lateral radiograph of the neck shows the typical "thumb sign" at the level of the epiglottis. The child must be attended constantly by personnel capable of handling difficult airways. A team should be assembled and the patient brought rapidly to the operating room. The operating room should be prepared for emergency bronchoscopy and possible tracheotomy. Oxygen supplementation should begin early. The child should be disturbed as little as possible. Intravenous (IV) access should be obtained after

induction of anaesthesia because it can cause crying and may exacerbate the airway compromise. Obviously, it is preferable to have IV access before the induction if it can be obtained without disturbing the child. Monitors before induction should include a precordial stethoscope, EKG, and pulse oximeter. The preferred technique by this author for induction of anaesthesia is mask inhalation keeping the patient breathing spontaneously. Halothane or Sevoflurane, nitrous oxide, and oxygen are used.²⁰ As you increase the sevoflurane concentration, decrease the nitrous oxide concentration until you are left with sevoflurane and 100% oxygen. Once the child loses consciousness placement of an IV and the rest of the monitors (blood pressure cuff and temperature) is accomplished.

Attempt laryngoscopy and intubation only after an adequate depth of anaesthesia has been obtained as judged by eye signs, blood pressure, heart rate, and conversion to quiet diaphragmatic breathing. Always maintain spontaneous ventilation if possible.

A nasal intubation is preferred for postoperative care, but an oral tube should be placed if any problems arise. If during the induction of anaesthesia complete airway obstruction ensues, a rapid laryngoscopy should be attempted and preparation for emergency cricothyrotomy made if the airway is not rapidly controlled. Once the airway is secure, blood cultures should be drawn and antibiotic therapy commenced. The patient is then transferred to the intensive care setting for postoperative management. Appropriate sedation should be administered in the intensive care unit (ICU) to prevent an accidental extubation, which could be a disaster. Narcotics or benzodiazepines are commonly used for sedation. Usually after 12 to 36 hours of IV antibiotics the patient can be extubated safely, and after a few hours of observation, may be transferred out of the ICU.

B. Macroglossia

The term macroglossia is applied when the tongue is too large for the oral cavity. The oral cavity may also be too small for a normal-sized tongue (pseudomacroglossia). Examples of conditions in which macroglossia is found include: lingual hemangiomas, primary macroglossia, mucopolysaccharidoses,²¹ AV malformations, solid tumors of the tongue and Down's syndrome.²²

Trauma and facial burns may also present with macroglossia.

Visualization of the larynx may require direct or indirect means. Direct laryngoscopy will be possible only if the tongue can be displaced to the left. If this proves to be difficult, indirect means are required to view the larynx. Options for the latter technique include a blind intubation via the nose or fiberoptic bronchoscopy. Recently, the addition of the "ultrathin" bronchoscope allows fiberoptic bronchoscopy to be performed even in small infants. The smaller bronchoscopes lack a suction channel and are more difficult to use. Use of this instrument requires prior

experience with normal and older children or adult airways before management of the difficult infant airway is attempted. "Blind" nasal intubation is more difficult in infants and small children than in adults because of the more anterior position of the larynx and therefore, the greater curve that the tube must make in the pharynx. Stylets and lightwands have been used to improve the success of this method. They can also be used blindly via the oral route. Other options in the management of the patient with macroglossia include the Bullard laryngoscope, retrograde intubation or the use of an LMA mask with subsequent intubation.

Infants and older children with intraoral and pharyngeal masses can be managed the same way as described above.

C. Micrognathia

Micrognathia means failure of the mandible to develop fully.

It may be the most the most important factor in predicting a difficult airway.²³ Two important disorders deserve mention here. They are the Treacher-Collins Syndrome and the Pierre-Robin Syndrome.²⁴ The mandible develops from the first branchial arch. The presence of preauricular skin tags or abnormally developed external ears, which also develop from the first branchial arch, may alert the clinician to the potential for a difficult airway.

The airways of infants and small children with Treacher- Collins or Pierre-Robin Syndromes may present with a tongue that may not be easily displaced during direct laryngoscopy, a more anterior larynx and a smaller oral aperture. Glossoptosis may further complicate the airway of patients with micrognathia.

Management of the airway is similar to that described above for the patient with macroglossia. We have found though that these patients can be intubated orally with direct laryngoscopy if the laryngoscope is inserted on the extreme right side of the mouth with posterior pressure on the thyroid cartilage. If unsuccessful, fiberoptic-guided intubation through the LMA or intubation with a "lightwand" may be accomplished.

D. Foreign Body Aspiration in The Airway

The aspiration of a foreign body in the airway is the leading cause of accidental deaths in paediatric patients under the age of one.²⁵ Infants can present in significant airway distress and respiratory insufficiency.²⁶ Thus the management of the airway can be a nightmare even for experienced anesthesiologists.²⁷ The history of a foreign body aspiration usually is very short, although at times there may be a 2 or 3 week interval between the apparent episode of aspiration of a foreign body such as a peanut and progressive symptomatology requiring medical attention.

A foreign body aspirated into the area of the larynx (laryngeal foreign body) usually presents with inspiratory stridor and bilateral breath sounds. At times these children are in extreme distress but unless they are unconscious they can be taken to the operating room for definitive treatment. Many times just with a laryngoscopy and a McGill forceps, the foreign body can be retrieved. General anaesthesia should be induced maintaining spontaneous ventilation if possible.

A foreign body at the level of the trachea will usually present with bilateral decreased breath sounds and both inspiratory and expiratory stridor. The chest radiograph should be a useful diagnostic tool. After the foreign body is discovered, laryngoscopy and bronchoscopy should follow as soon as possible. An inhalation induction with the patient breathing spontaneously is preferred. Sometimes it takes time and patience to appropriately induce the patient. After the patient is judged to be reasonably "deep" under anaesthesia, he or she is turned to the surgeon for insertion of the bronchoscope and removal of the foreign body. One has to remember also that usually these patients are considered a "full stomach" but waiting for the stomach to empty is not appropriate because the excitement of the episode will delay gastric emptying. If during the case complete airway obstruction arises, the foreign body needs to be extracted rapidly or pushed down to usually the right mainstem bronchus.

This sometimes can be life-saving. If the foreign body is beyond the level of the trachea, the physical examination will reveal uneven breath sounds. The respiratory distress may not be as severe as when the foreign body is in the trachea.

After the foreign body is retrieved, the patients should be intubated and then awakened. Some patients may require the use of racemic epinephrine and/or steroids to reduce the inflammation and edema that is associated not only with a foreign body but also with the instrumentation that will be required to remove it. Many surgeons also order a chest radiograph after the instrumentation to rule out any trauma caused by the instrumentation.

E. Paediatric Trauma

One of the most important aspects in the perioperative care of the paediatric trauma victim involves the management of the airway.²⁸ There are several factors that contribute to the potential of airway obstruction in this patient. They include loose teeth and foreign bodies, blood and secretions, peri-oral and tongue swelling, laryngeal and tracheal ruptures and food aspiration.

Initial assessment should determine adequacy of ventilation.

Inspection and auscultation of the chest should be performed immediately. If the

patient is not breathing, immediate therapy should be provided resulting in a secured airway. Physical examination of children in respiratory distress may reveal nasal flaring and grunting; suprasternal, subcostal and intercostal retractions. The child's small size and short neck makes the assessment of the neck for tracheal position and jugular venous distention difficult. Pallor, cyanosis, and an altered level of consciousness are late signs of respiratory insufficiency and/or failure and demand immediate intervention. Initial management of the patient should also include monitoring of pulse oximetry, end-tidal CO₂ and arterial blood gases. Supplemental oxygen should be given to all trauma victims until a definitive diagnosis can be obtained. Indications for endotracheal intubation include inadequacy of oxygenation and/or ventilation, loss of consciousness in order to protect the airway against aspiration, and in patients in which hyperventilation for increased intracranial pressure is needed.

Cervical spine injury in children is uncommon, especially in young infants, whose injuries tend to be at a high cervical level. Trauma, though, can in some cases render the spine unstable especially in patients with Down's Syndrome. So, excessive movement of the head and neck in the paediatric trauma victim should be avoided. In-line stabilization should always be maintained when airway manipulation is attempted.

The diagnosis of cervical spine injury is more difficult in the paediatric patient when compared to the adult patient.²⁹

Therefore, any child with a suspected neck injury should have cervical spine precautions (i.e. neck collar) and receive an extensive radiographic and neurologic evaluation. Because there is usually no time for this in the emergency victim presenting to the operating room, an assumption of an "unstable" neck should always be made and in-line stabilization maintained during intubation attempts. Even on patients that have had neck radiographs, the cervical spine may not be entirely cleared.

Many times the x-ray does not include a view below C₆, the odontoid process is not seen, and/or pseudosubluxation of C₂ to C₃ or C₃ to C₄ may occur and be missed.

The actual intubation sequence will be determined by the clinical situation. If the patient has stable vital signs and an anticipated normal airway, a rapid sequence induction and intubation with cricoid pressure may be performed. This is usually the most commonly utilized technique. Thiopental, propofol, ketamine and etomidate are frequently used induction agents in the stable victim.

If the patient has extensive injuries and is hemodynamically unstable, ketamine or

etomidate is preferred. In the head-injured child, ketamine is contraindicated because it increases intracranial pressure. Etomidate decreases intracranial pressure and is less of a myocardial depressant than thiopental or propofol, so it should be the agent of choice in the unstable patient.

Alternate approaches should be considered in patients in whom a difficult intubation is anticipated. An awake intubation with spontaneous ventilation may be attempted although this may be impossible in a struggling child. A variety of laryngoscope blades and airway equipment discussed before may be used in these patients. The Bullard laryngoscope, because of not having to align the different airway axes, may be a good choice. Also, the lightwand and the fiberoptic bronchoscope. A laryngeal mask airway may also be useful as long as an endotracheal tube is placed through the LMA to protect the airway from aspiration.

Inability to establish a clear airway will most likely require surgical intervention.

The Advance Trauma Life Support

Course recommends a needle cricothyrotomy as the preferred method recognizing it only as a temporary method. However, gas exchange may be inadequate by this method and significant barotrauma may occur.

6 Summary:

One of the biggest "nightmares" for anaesthesiologists is the management of the child with a difficult airway. A thorough understanding of the anatomical and physiological differences between children and adults is critical for the successful management of this airway. Recently, a number of different types of "airway" equipment have become available in small enough sizes to be used even in the smallest of infants. This coupled with a careful planning and a thorough and comprehensive history and physical examination should aid in the optimal management of the paediatric difficult airway.

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TABLE 1

ANATOMICAL FEATURES OF THE INFANT'S AIRWAY

- The infant's larynx is higher in the neck. In the premature infant it is located at mid-third cervical vertebra (C3), in the term infant between C3 and C4, and in the adult between C4 and C6.
- The infant's tongue is relatively large
- The epiglottitis is short, stubby and angled away from the axis of the trachea
- The vocal cords have a lower attachment anteriorly than posteriorly
- The narrowest portion of the airway is the level of the cricoid cartilage, while in adults it is the glottic opening

TABLE 2

AIRWAY "GADGETS" IN PEDIATRICS

- Laryngeal Mask Airway (LMA)
- Flexible Fiberoptic Bronchoscope (FFB)
- Bullard Laryngoscope
- Lightwand
- Shikani Seeing Optical Stylet (SOS)
- Angulated Video-Intubation Laryngoscope (AVIL)

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POST STUDY QUESTIONS

1. The infant's larynx is located:
 - A. Lower in the neck than the adult.
 - B. Between C3 and C4.
 - C. Between C4 and C5.
 - D. Between C5 and C6.
 - E. Lower than C6.
2. One of the characteristics of the upper airway in the infant is:
 - A. The tongue is relatively small.
 - B. The epiglottis is positioned low in the pharynx.
 - C. The tonsils and adenoids appear usually during the first six months of life.
 - D. The narrowest portion of the airway is at the cricoid cartilage.
 - E. The posterior commissure is more caudal than the anterior commissure.
3. Which of the following is an infant's characteristic in regard to respiratory function:
 - A. More oxygen reserve than the adult.
 - B. Higher metabolic rate with increased oxygen consumption.
 - C. Low alveolar ventilation.
 - D. Low respiratory rate.
 - E. Functional residual capacity (FRC) is increased in infants by general anesthesia.
4. Which of the following is correct about airway equipment:
 - A. The laryngeal mask airway (LMA) may be used as a conduit for an endotracheal tube (ETT).
 - B. Unfortunately, the fiberoptic scope cannot be used in a small infant.
 - C. The Bullard laryngoscope requires the alignment of the oral and pharyngeal axes.
 - D. Blood and secretions are impediments to the use of the lightwand.
 - E. Lightwands cannot be used in abnormal airways.
5. Preoperative anesthesia considerations include:
 - A. The history of the patient is not important.
 - B. Transesophageal ECHO.
 - C. A thorough physical examination of the airway.
 - D. Premedication should always be used to calm the patient.
 - E. Anticholinergic agents are not necessary.
6. The induction of anesthesia in the difficult airway:
 - A. Type I patients should always have an awake intubation.
 - B. Type II patients present to the operating room for the first time.
 - C. The fiberoptic scope is very useful in the Type III patients.
 - D. Type IV patients never need a surgical airway.
 - E. Always use a muscle relaxant to facilitate intubation.

7. In the unexpected difficult intubation:

- A. Direct laryngoscopy should be attempted until successful.
- B. The fiberoptic scope is never useful.
- C. The important thing is not to panic.
- D. The patient may need more muscle relaxants.
- E. The patient will not accept an LMA.

8. In pediatric trauma:

- A. Initial assessment should determine adequacy of ventilation.
- B. Nasal flaring is not seen in children in respiratory distress.
- C. Supplemental oxygen is not needed unless the oxygen saturation by pulse oximetry is low.
- D. Cervical spine injury in children does not occur because of their anatomic differences.
- E. An awake intubation is the most common intubation.

9. The patient with micrognathia:

- A. The mandible develops from the fourth branchial arch.
- B. Preauricular skin tags are a good clinical sign of macroglossia.
- C. Inserting the laryngoscope on the left side of the mouth may help in the intubation.
- D. Glossoptosis is not a factor.
- E. Fiberoptic guided intubation through the LMA is a reasonable approach in these patients.

10. In patients with acute epiglottitis:

- A. The most frequent causative agent in children is staphylococcus aureus.
- B. The patient prefers to lie supine because they can breath better
- C. The lateral radiograph of the neck shows the typical “thumb sign”.
- D. The child should be intubated in the emergency room.
- E. Fluid resuscitation is necessary before induction of anesthesia.



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