BILATERAL INTERNAL JUGULAR PHLEBECTASIA IN AN ADULT*

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Abstract

Objective:
To report a case of bilateral internal jugular phlebectasia in an adult and promote awareness of the disease.

Design: Case Report

Setting: Tertiary Government Hospital

Patient: A 22 year old male with bilateral neck masses.

Results:
The most common neck mass appearing on straining is a laryngocele. However, phlebectasias of the internal jugular vein may have a similar presentation. The disease usually presents unilaterally and in children. However this case involves an adult with bilateral involvement. The possible etiology and the management are discussed.

Conclusion:
Internal jugular phlebectasia may occur bilaterally in adults.

INTRODUCTION

Neck masses are one of the most common complaints encountered by the otorhinolaryngologist-head & neck surgeon. However, it is often one of the most difficult to diagnose, because the neck is an area containing various structures with their corresponding number of possible diseases. These masses may range from the simple lymphadenitis to the more complex neoplastic neck masses.

Even the most experienced clinician can still be misled by rare masses or common masses with rare presentations.

Technology has improved diagnostic speed and accuracy, yet it is still the knowledge, skill and experience of the clinician, which guides in the evaluation and management of these cases.

According to Sanjay et al., the most common neck masses that appear or enlarge during straining are laryngoceles and pharyngoceles. However, anomalous dilatation of the jugular veins may also have the same presentation and should be included in the differential diagnoses.

In 1928, Harris diagnosed a 5 month old infant to have a “congenital venous cyst”. This was later called “phlebectasia” by Gerwig in 1952. Since then there have been relatively few cases published. In the few published cases, the jugular phlebectasias described were mostly unilateral and mostly found in children. In 1992, R.M. Walsh published a case of bilateral internal jugular phlebectasia in a child. A case of unilateral jugular phlebectasia involving Filipino twins was reported by Del Rosario, et al in 1997.

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CASE REPORT

P.E., a 22 year old, male, from Marikina City who was seen at the ENT Department due to bilateral neck mass appearing during straining and swallowing. (Fig. 1)

![Image](image1)

Fig. 1. The patient at rest and at Valsalva

The condition started seven months prior to consult, when he felt tightness on his neck after lifting buckets of water. Upon self-examination, he noticed a mass on the left lateral area of his neck appearing every time he swallows. No consultation was done. It was noted to be progressively enlarging with each appearance.

Four months prior to consult, he noted a similar mass appearing on the right side of the neck, with both neck masses enlarging on straining and disappearing on relaxation. Persistence of the said symptoms prompted consult at our outpatient department, where an initial impression of Laryngocele vs. Pharyngeal Diverticulum was given.

Review of systems showed no associated symptoms. The patient had no previous hospitalization or any known illnesses. Family history was unremarkable and no other relative had the same complaint. The patient is a non-smoker and an occasional alcohol beverage drinker.

Laryngoscopic findings showed no laryngeal masses, no bulging of the false vocal cords and good vocal cord mobility. Palpation of the neck during Valsalva, revealed a mass which was soft, cystic, nontender, measuring 6 x 5 x 2 cm on the left and 5 x 5 x 2 cm on the right, appearing as a continuous mass above the clavicles and sternum, lifting and pushing the sternocleidomastoids anteriorly. No pulsations or thrills were noted. Auscultation of the mass showed no bruits. The mass is not evident in the resting state. A pharyngoesophagogram showed unremarkable findings. (Fig. 2)

A neck ultrasound revealed elongated tubular cystic structures noted on both sides of the neck that dilates during valsalva maneuver. Both were noted to be laterally located in relation to the thyroid gland and carotid arteries, suggestive of a vascular anomaly. The cystic structures were measured at 48 x 14 x 18 mm on the right and 40 x 10 x 23 mm on the left.
A CT scan with contrast infusion done revealed prominent segments of both internal jugular veins at the levels C7 to C5. The largest cross-sectional area was at level C6 to C7 measured at 2.64 cm x 2.5 cm on the right and 2.45 cm x 2.5 cm left, during valsalva. Compared to a resting area of 1.2 cm x 2.24 cm on the right and 1.99 cm x 1.4 cm on the left. This represents an area increase of 145% on the right and 110% on the left. At level C4, cross-sectional area during valsalva was at 1.4 cm x 1.4 cm on the right and 1.5 cm x 1.5 cm on the left. Compared to a resting area of 1.3 cm x 1.3 cm on the right and 1.4 cm x 1.4 cm on the left. This represents an area increase of only 16% on the right and 15% on the left. (Fig. 3, 4 & 5)
The case was diagnosed as a bilateral internal jugular phlebectasia. The patient was advised to avoid strenuous activities and monthly follow-up.

**DISCUSSION**

The case presented a young adult male with bilateral soft, cystic, anterior neck masses. A progressively enlarging neck mass may give an impression of an infectious process or a malignancy. However, the patient did not show signs of inflammation (rubor, tumor, calor, dolor) to indicate an infection. Malignant neck masses would often be solid or hard. According to Sanjay et al., differential diagnoses to consider for cystic neck masses that appear on straining would include laryngoceles, pharyngoceles, superior mediastinal tumors/cysts and jugular phlebectasia.

A laryngocele and a pharyngocele may be ruled out since these are usually accompanied by hoarseness, stridor, dysphagia, sore throat, snoring and cough, all of which were absent in our patient. Furthermore, the following findings may rule out the presence of a laryngocele. Firstly, absence of swelling in the false cords on laryngoscopy. Secondly, the external component of a laryngocele would have been located medially and higher at the level of the thyrohyoid membrane in contrast to our patient where it was found laterally and at about the level lower than the cricoid cartilage. Finally, there was absence of an air-filled sac in the larynx on CT scan. The clinical and radiologic findings in the pharynx ruled out a diagnosis of a pharyngocele or a diverticulum. Radiologic findings in the chest showed no indications of the presence of superior mediastinal tumors and cysts.

Anomalous fusiform or saccular dilatations of veins have been called by various names including phlebectasia, venous aneurysm and congenital venous cysts. Because anomalies of the internal jugular vein are not common with only a few cases being encountered in clinical practice, Sanders et al (1999) conducted a survey on physicians' awareness of the disease. The study reported that 96% of pediatricians, 37% of otolaryngologists and 40% of pediatric surgeons have no idea of what a jugular phlebectasia is.

According to al-Dousary (1997) internal jugular phlebectasia is a rare disease mostly found in children and frequently unilateral usually involving the right. La Monte (1976) stated that internal jugular phlebectasia is a clinico-radiologic diagnosis, consisting of findings of a neck mass that appears
BILATERAL INTERNAL JUGULAR PHLEBECTASIA

with straining and a radiologic finding of a localized dilatation of the internal jugular vein.\(^8\)

No predisposing factors for jugular phlebectasia have been found. According to studies by Burstin, Nwako, and Yokomori, these anomalies may occur during the development of the internal jugular veins, as a congenital muscle defect or thinning in the tunica media of the vascular walls.\(^9\),\(^10\),\(^11\) In another study, by Brearley et al. it was found that jugular phlebectasia also occurs in patients with Ehlers-Danlos syndrome. This syndrome is characterized by abnormal collagen synthesis.\(^12\) This may contribute to weakening of the vascular walls resulting in phlebectasia.\(^13\) A case report by Teodorescu in 1978 mentions an occurrence of a post-traumatic jugular phlebectasia.\(^14\) It is believed that the patient in our case has a congenitally weak jugular venous wall and the repeated straining caused the weakened walls to balloon out and form the neck mass as stated in the case history.

According to Schatz et al. (1962) phlebectasias in adults occur more commonly in the superior vena cava, portal, greater and lesser saphenous, splenic, femoropopliteal and facial veins.\(^15\) Our case involved both internal jugular vein in an adult.

Contrast enhanced CT scan and plain ultrasonography are non-invasive procedures preferred by some investigators as diagnostic modalities.\(^1\) In some institutions, Color Doppler Ultrasonography is the preferred method of diagnosis because of its ability to detect blood flow.\(^16\) We used ultrasonography and contrast enhanced CT scan since these are the modalities available in our institution.

Internal Jugular Phlebectasia is a benign disease. According to La Monte treatment should consist of observation and assuring both the parents of children and/or patient that the condition produces no morbidity or disability and will not progress to a more serious problem.\(^8\) Al-Dousary (1997) stated that surgical management of internal jugular phlebectasias constitutes unilateral resection and is reserved for cosmetic or psychological purposes.\(^17\) However, Walsh et al. (1992) recommends conservative management for bilateral cases to avoid compromising venous drainage from the brain.\(^2\)

We presented a case of a 22 year old male who presented with a bilateral neck mass of 7 months duration which appeared during swallowing and straining and was found to be dilated segments of both internal jugular veins by ultrasound and CT scan. This is an adult onset bilateral jugular phlebectasia.

CONCLUSION

To the best of the author’s knowledge, no case of an adult onset bilateral jugular phlebectasia has been previously published. With the presentation of this case, clinicians may be informed of the existence of internal jugular phlebectasias, the possibility of its bilaterality and its occurrence in adults. These facts may help increase the clinician’s level of suspicion when presented with an adult with a cystic neck mass and avoid unnecessary procedures such as biopsies, incision, or excision which may lead to severe hemorrhage and possibly death.\(^10\)

REFERENCES

# TABLE OF CONTENT

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDITORIAL STAFF</td>
<td>1</td>
</tr>
<tr>
<td>GUIDELINES FOR AUTHORS</td>
<td>i</td>
</tr>
<tr>
<td>EDITORIAL</td>
<td>1</td>
</tr>
<tr>
<td><strong>PRESIDENT'S INAUGURAL ADDRESS</strong></td>
<td>2</td>
</tr>
<tr>
<td>Edgardo C. Rodriguez, Jr., MD</td>
<td></td>
</tr>
<tr>
<td><strong>SPECIAL ARTICLES</strong></td>
<td></td>
</tr>
<tr>
<td>A TRIBUTE TO DR. ANGEL ENRIQUEZ</td>
<td>3-7</td>
</tr>
<tr>
<td>Joselito C. Jamir, MD; Agnes N. Tirona-Remulla, MD</td>
<td></td>
</tr>
<tr>
<td>COCHLEAR IMPLANTATION: THE PHILIPPINE GENERAL HOSPITAL EXPERIENCE</td>
<td>9-13</td>
</tr>
<tr>
<td>Charlotte M. Chiong, MD</td>
<td></td>
</tr>
<tr>
<td><strong>ORIGINAL ARTICLES</strong></td>
<td></td>
</tr>
<tr>
<td>ABACA (Musa Textilis) AS AN ALTERNATIVE SUTURE: A COMPARATIVE STUDY OF TISSUE REACTION AND TENSILE STRENGTH</td>
<td>15-24</td>
</tr>
<tr>
<td>Christine O. del Monte, MD; Romeo L. Villarta, MD;</td>
<td></td>
</tr>
<tr>
<td>Teresa Luisa I. Gloria-Cruz, MD; Abegayle Machelle M. Perez, MD</td>
<td></td>
</tr>
<tr>
<td>ACCURACY OF 512 HERTZ AIR CONDUCTION TEST FOR HEARING SCREENING</td>
<td>25-33</td>
</tr>
<tr>
<td>Neil Aldrin I. Penaflor, MD; Oscar Hilario, MD;</td>
<td></td>
</tr>
<tr>
<td>Generoso T. Abes, MD</td>
<td></td>
</tr>
<tr>
<td><strong>CASE REPORTS</strong></td>
<td></td>
</tr>
<tr>
<td>PIG BRONCHUS: A CASE REPORT OF A TRACHEOBRONCHIAL ANOMALY</td>
<td>35-41</td>
</tr>
<tr>
<td>Ferdinand Gabriel C. Cordero, MD; Peter George J. Tian, MD;</td>
<td></td>
</tr>
<tr>
<td>Gil M. Vicente, MD; Antonio H. Chua, MD</td>
<td></td>
</tr>
<tr>
<td>BILATERAL INTERNAL JUGULAR PHLEBECTASIA IN AN ADULT</td>
<td>43-48</td>
</tr>
<tr>
<td>Franco Rommel L. Reyes, MD; Celso V. Ureta, MD;</td>
<td></td>
</tr>
<tr>
<td>Gerardo E. Cruz, MD; Reynaldo Z. Astorga, MD;</td>
<td></td>
</tr>
<tr>
<td>Ephraim Eduardo, MD</td>
<td></td>
</tr>
</tbody>
</table>
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THE PHILIPPINE JOURNAL OF OTOLARYNGOLOGY
HEAD AND NECK SURGERY

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Abstract: A 5-15 sentences abstract to precede article.

All manuscripts and other editorial matter should be addressed to Charlotte M. Chiong, MD, Editor-in-chief. The Philippine Journal of Otolaryngology-Head and Neck Surgery, Department of Otolaryngology, UP-PGH, Taft Avenue, Manila.
The Philippine Journal of Otolaryngology Head and Neck Surgery

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Editorial

The Philippine Journal of Otolaryngology Head and Neck Surgery (PJO-HNS) is celebrating its 20th anniversary. In this anniversary issue it is but fitting to pay tribute to the founding editor and father of the PJO-HNS, Dr. Angel E. Enriquez. Indeed, like a doting father he nurtured the journal from its infancy and at the helm of early publication he ensured the long term viability of the PJO-HNS. As the repository of research in Philippine Otolaryngology it does mirror the remarkable growth of our professional organization, the Philippine Society of Otolaryngology-Head and Neck Surgery and its now pre-eminent stature in Philippine Medicine. One cannot help but marvel at how our specialty has grown in its breadth and depth and how it has attracted more and more enthusiastic young doctors into dedicating their lives to otolaryngology–head and neck surgery. Judging from the increased number of researches being done in the different institutions, the attendance in meetings and academic conferences, post-graduate courses offered and the increasing number of colleagues taking postgraduate courses in related fields of clinical epidemiology, audiology as well as the increasing number of those obtaining post-residency fellowships our specialty is not only thriving but expanding.

The editorial staff plans to add more sections to upcoming issues such as a pathology case review section, review articles, ENT-news and announcements from the PSO-HNS. Proceedings of our meetings and annual conventions will likewise be published in the future. Upcoming issues will also be posted in our website for wider access to members of the PSO-HNS and our other colleagues. Schering-Plough has agreed to make an unrestricted educational grant to the PSO-HNS by sponsoring the publication of this journal. They have done this for the last two years and we hope they will continue to do so for many years to come. Of course, they deserve our utmost thanks.

I would like to thank Dr. Joselito Jamir for this issue’s flagship article. As previous editor of the PJO-HNS I witnessed his untiring efforts to improve the journal. The immediate past editor Dr. Jose Acuin must likewise be acknowledged for his efforts to come up with quarterly issues in pursuit of the goal for the PJO-HNS to be indexed by Medline and the Index Medicus. It is my hope that I can help achieve this goal. I would like to encourage you readers to contribute your share by sending your manuscripts for consideration by the editorial staff, even if these have not been presented in research fora. Let me thank in advance the rest of the editorial staff who I am sure will give of their time and talent generously to make their worthwhile contribution to the journal. It is with deep gratitude that I acknowledge the efforts of Dr. Abner Chan who served well as senior associate editor for this issue. In future issues the associate editors for the different subspecialties will have the first crack at reviewing the manuscripts. In special situations, outside reviewers from other related specialties like pathology, epidemiology, and audiology will be invited. There may be special issues on more relevant or contentious issues confronting our specialty for which a guest editor will be invited. Last but not least let me also thank Dr. Edgardo Rodriguez, President of the Philippine Society of Otolaryngology Head and Neck Surgery for this opportunity to serve the PSO-HNS as editor-in-chief of this journal. My personal motivation in accepting this exciting new challenge, a serious albeit welcome responsibility is no other than to contribute to the specialty I and my family love. It was my father Dr. Army Chiong (past UP-PGH ENT department chairman) who introduced otolaryngology to me but it was my uncle Dr. Vic Chiong (past UST ENT department chairman) who sparked my fascination with the ear.

CHARLOTTE M. CHIONG, M.D., FPSO-HNS
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INAUGURAL ADDRESS
EDGARDO C. RODRIGUEZ, JR., MD
President,
PHILIPPINE SOCIETY OF OTOLARYNGOLOGY-HEAD AND NECK SURGERY

It is my honor to be inducted as the new President of the Philippine Society of Otolaryngology—Head and Neck Surgery. It is also an honor to present to you the new officers of the PSO-HNS.

In line with our vision to create a sharper and better-coordinated policy-making body responsive to the needs and interests of its members, we have added new committees to our organization.

The Membership Committee is now studying and processing the possible inclusion of the Rhinology Study Group, Laryngectomee Club, and the Otology Group. It shall also be addressing several matters concerning our practice through these subspecialty groups.

The Legal Aid Subcommittee aims to provide assistance to our fellows on legal matters and medico-legal problems. This will be facilitated by retaining a medico-legal officer on per-case basis.

Mutual Fund Subcommittee intends to establish mutual benefit plans for our members.

The Sports and Recreation Subcommittee shall provide our members with year-long activities to establish camaraderie and eliminate conflicts. As of present, negotiations are ongoing with possible sponsors for tournaments on golf, basketball and volleyball.

Problems besetting our society concerning our practice have been previously identified and we shall be addressing them accordingly. We will continue to negotiate for better surgical and bedside rates with the HMOs. We have increased the members of the committee who are in close contact with the HMO executives. Regarding the head and neck cases, we have pursued for representation in the Philippine College of Surgeons (PCS). Last December, Dr. Abes, our out-going President, was elected to the Board of Governors of PCS. Thus, we will now have a stronger voice in the said organization.

As to our relationship with the Philippine Board of Otolaryngology-Head and Neck Surgery (PBO-HNS), initial talks with some of its members have been very enlightening and constructive. Their willingness to change has been noted. We will continue this rapport.

With regards to training, we will review and try to standardize all training programs. Added to this, we have created a subcommittee on medical and surgical missions to augment the different training programs and increase public awareness of our society and its activities.

Lastly, we intend to transfer to our new and permanent office at the Espana Towers by February. I hope to see you there soon.
A Tribute to Dr. Angel E. Enriquez

Joselito C. Jamir, MD
Agnes N. Tirona-Remulla, MD

It is both an honor and a privilege for me to deliver the inaugural Enriquez Memorial Lecture. Through the past three or four months I have been wondering why I was chosen to do so. Was it because I am close to the members of the Southern Luzon chapter who masterminded this very brilliant idea of honoring a man whose dedication to our specialty and to the society is beyond compare? Was it because I nurtured the seed that he planted in the name of the Philippine Journal of Otorhinolaryngology-Head & Neck Surgery which he fathered and for which he served as editor during its infancy? Certainly, it was not because of the moments we spent sharing our dreams and thoughts about our specialty since our colleagues from Ospital ng Maynila would claim that, if this were the sole category, their present chair would win hands down. I suppose the reason was bluntly made clear to me by Dr. Jose Acuin when he introduced me on one occasion as the most senior endoscopist in the country today since the acknowledged one had recently passed away.

Forgive me, ladies and gentlemen, if I may not humor you tonight with a scientific lecture on the subspecialty that Dr. Enriquez and I have loved so much. Besides, endoscopy is something that you can never lecture on. It is something that is simply too irresistible. You just have to see it, feel it, imagine it and finally — extract it. After all has been said and done, you simply have to savor your one shining moment. For that is what bronchoesophagology is all about, that one shining moment in time. And that is exactly what Dr. Angel Enriquez is all about. In his lifetime, he shone as bright as any visionary did. And his beam reached far and wide. He touched all our lives with his dreams, his ideas, his work. In his passing, he left a legacy many of us are still struggling to keep up with. Please allow me to humor myself tonight by letting me share with you what I know of this great man.

Dr. Angel Enriquez was born on July 19, 1925. He graduated from the University of the Philippines College of Medicine in 1952. He attended the Basic Course in Otorhinolaryngology at the University of Pennsylvania Graduate School of Medicine and subsequently completed his residency in ENT at the University of Pennsylvania Hospital in 1956. This is where he had the chance to work with the Chevalier Jacksons, father and son, considered the prophets of endoscopy. In 1965, he married the former Flor Minoreca with whom he had 2 children, Charles Howard and Michelle. He became the Chairman of the Department of Otorhinolaryngology at the Ospital ng Maynila from the time the ENT and Ophthalmology became separate departments until his retirement in 1990. He was editor-in-
chief of the Philippine Journal of Otolaryngology – Head and Neck Surgery from 1981 to 1988 and the Medical Journal of the PLMCM-ONM and Ospital ng Maynila Research Journal in 1987. From 1960 to 1985, he became the Chairman of the Department of Otorhinolaryngology at the Manila Central University – Filemon D. Tanchoco Medical Foundation and was a past president and initial constituents of the Philippine Board of ORL-HNS. Dr. Enriquez had that distinct privilege, being connected with all the initially accredited departments.

Dr. Enriquez was very unassuming, very humble. But he had the strength of character and unwavering principles that would put many to shame. At no other time was this more evident than when he fought for his men who were under siege.

As some of us may recall, an unfortunate incident abruptly terminated his official relationship with MCU. During this period of crisis, he spent his resources waging that battle and was magnanimous in his hour of victory.

His dedication to the institutions he served was absolute. With his official separation from MCU, he continued to exercise influence through the men and women he trained. Such was also the case with Ospital ng Maynila. Upon nearing his retirement, he had a quandary on his

founding fellow of the Philippine Society of Otolaryngology – Head and Neck Surgery.

Allow me then to tell you the little secrets that Dr. Enriquez and I have shared through the years. Although it was my good friend Ed Jose who initiated me into endoscopy, it was Dr. Enriquez who cultivated it. And he shared with me more than just professional advice. Through years of conversations I have gained much insight into his dreams, thoughts, ideas and his frustrations as well.

Dr. Enriquez has always believed in our specialty. To this effect, he established and headed the ENT departments at the Ospital ng Maynila and was the moving spirit of the same department at the Manila Central University Hospital. If my memory serves me right, aside from the Philippine General Hospital, these are the two departments that were the
choice of possible successor. Being the vultures that we at PGH are, we lobbied for a PGH man to be chosen as the anointed one. Dr. Enriquez simply used that Mona Lisa smile of his. Later on, when we had the opportunity to talk in private, he confided that he would rather go for one of his homegrown boys at OM. So there you are Eddie Boy Rodriguez, Dr. Enriquez has a lot riding on you. He expected you to follow in his footsteps but never in his shadows. Your achievements will be the validation of his faith.

His dedication was not only to the institutions he served but also to the individuals that would eventually become otolaryngologists. For those who took the specialty board exams during his years of stewardship, few would realize how Dr. Enriquez agonized over decisions that may be taken by the board. He was aware that professional futures and lives were at stake in the determination of the passing grade. Being the pakialamero that I have always been, Dr. Enriquez would command me to make the computations of the various grades, coded of course, using different variations and then he would make his recommendations to the board. He would see to it that the most reasonable figures were arrived at. At one point, he even considered discarding the grades in one exam where everybody apparently failed since the highest grade was only 37 and some candidates even got a grade of 0. That was how considerate he was. But he was only one member of the board. As he would like to state, "If justice is to rule the world, we are all in trouble". Ironic but true, is it not? He often said that reality is the most stressful thing in life for those who are in touch with it. He definitely was one. Just imagine the pain he suffered whenever the board met to deliberate on the fate of the examinees.

Around 15 years ago, Dr. Angel Enriquez broached to some of us the idea of establishing the Philippine Academy of Ear, Nose and Throat in order to take over all the continuing education functions of the society. The concept was even presented to the board for its imprimatur. He argued that it is a way of standardizing the course content as well as rationalizing the schedule of post-graduate courses. To an extent, this is what our current president, Dr. Generoso Abes is pursuing when he vigorously put into action the society’s academic committee headed by Dr. Edgardo Rodriguez and which Dr. Jimmy Flor has included in his platform. With these two guys actively campaigning for the presidency of the society, I am sure that Dr. Enriquez’s concept will finally become a done affair. This again is a manifestation of his wisdom. As he would like to put it, "A handful of patience is worth more than a bushel of brains”.

The path to enlightenment requires open eyes and willing feet. Dr. Enriquez certainly did more than his share during his lifetime. And on top of that, he was able to inspire a lot more. When we were writing the textbook Basic Otorhinolaryngology, he was the one who not only contributed his share of the task but also volunteered for more work. He went through a lot of the manuscript and even accepted the position of editor. And he was one hell of a worker. "Nakakahiya" if you could not keep up with his schedule and work ethic. In this day and age of electronic communication, we are now in the process of converting the textbook into CD format. This is what Dr. Enriquez would have expected of us.

For most, Dr. Enriquez remains an enigma.
He is resolute and unwavering in his decisions but it must be understood that such decisions were the result of deliberate consultation and contemplation. I know this for a fact because I had been, on more than one occasion, his sounding board. I really enjoyed those moments not because of the importance he bestowed upon me but rather for the privilege and trust I was given when he took me into his confidence. To tell you the truth, it involved not only moments since each occasion lasted for hours. We threw at each other ideas, refining concepts, discussing strategies and adopting plans of action. It is easier to curse the candle than to light the darkness. Dr. Enriquez, the angel that he was, is not guilty of this.

At one point in time, he said that I was simply ahead of my time and that he would like to see the Shangri-La Plaza. He had attended the session despite just having been released from the hospital only the previous day. If that was not dedication and commitment, what can you call it? He took me aside and uttered, “Che, I have read the dedication you wrote in the journal. I am greatly flattered by what you have written about me.” The decision to dedicate that issue of the journal to him was brought about by a sincere desire to honor and acknowledge the contributions this unassuming man has made in the thing he loved most after his family. But then, he had more to say—“Kaya lamang ang aga mo yata akong pinatay! Parang obituary!” Can you just imagine how guilty I felt after that? The last statement may have been made in jest but, knowing him, it was a reiteration of the desire to live longer.

We were well aware of the precarious state of his health then but he would not allow even those of us who felt deeply for him to visit him at his hospital bed. He wanted to be remembered as he was during his prime. Do you still recall this picture? That was what it was all about!

I fully realize that a good number of those present here tonight can say a lot more about the man. About his life, his work, his character, his visions. But I feel extremely blessed for he was my teacher, my co-worker, my mentor and more importantly, my friend and confidant. There is more to the man than what has been stated by yours truly. I am certain he would have wanted to temper me with his belief that, “people who spout platitudes have attitudes that allow no latitudes”. Now I say, this man deserves all the platitudes many of us have
failed to give him in his lifetime. He was one of the greatest thinkers our field has ever had.

He had vision and he made it happen. He was a leader and he made leaders out of followers. He was our guardian and he made certain we did not get lost.

Edith Wharton once said, "there are two ways of spreading light: to be the candle or the mirror that reflects it." Dr. Enriquez was our candle and many of us, in turn, have become the mirrors that reflect his brilliance. This is Dr. Angel Enriquez, the great man that I remember. Dr. Angel Enriquez was everything I have said and more.

Truly, he was a gentleman in its fullest sense!
Cochlear Implantation: The Philippine General Hospital Experience*

Charlotte M. Chiong, M.D., FPSO-HNS**

Cochlear implants are electronic devices used to provide auditory sensation and information to children or adults with bilateral sensorineural hearing loss: profound to severe; acquired or congenital. They have proven to be a safe, reliable and effective means to perceive speech as well as for speech and language acquisition in children born with severe to profound deafness.

ANATOMIC CONSIDERATIONS:

The cochlea is the human organ of hearing and consists of the membranous structure called cochlear duct which is about 32-33 mm in length and twisted into a spiral with about 2 2/3 turns. There are three fluid filled spaces called the scala vestibuli, scala media and scala tympani. The hair cells which are responsible for transduction of sound energy into neural activity are organized as the organ of corti which lies upon the basilar membrane within the scala media. The otic capsule is the bony skeleton that encloses the cochlear duct except in 2 areas, the oval window which has the stapes that participates in the transmission of sound energy to the cochlear fluids and the round window composed of a compliant membrane along the inferior margin of the scala tympani near its basal coil that serves as an “escape route” of the fluid pressure waves.

The auditory nerve consists of about 30,000 bipolar primary afferent neurons and 1000 efferent nerve fibers. The neuronal cell bodies form the spiral ganglion which is located inside the modiolus. The spiral arrangement of neurons is a result of the tonotopic innervation of the organ of corti wherein the more basal fibers are responsible for high frequency hearing while the apical fibers allow low frequency hearing. The spiral ganglion cells are greatest in number between the upper basal turn and the middle turn of the cochlea.

There are two types of hair cells. The inner hair cells are mainly responsible for hearing while the outer hair cells fine tune this hearing. At the base of hair cells are the nerve fibers which are connected to the spiral ganglion neurons. In the spiral ganglion 95% are type I afferent neurons with large cell bodies that have myelin sheath and innervate inner hair cells while 5% are type II which are noticeably smaller without myelin and innervate the outer hair cells of the organ of corti. There is evidence of postnatal maturation of these spiral ganglion cells in the newborn and infants (Chiong et al, 1994) meaning that there will still be changes in the proportion of these cells during the first few months of life. From these spiral ganglion neurons arise central axonal processes that traverse the internal auditory canal and enter the brain. Therefore, when a person has hearing loss it is always important to know which part of this pathway, from the cochlea to the brain there is a problem. Fortunately the latest medical technology now allows us to localize the problem with some tests.

For example otoacoustic emissions testing allow assessment of hair cell integrity within the cochlea while brainstem auditory evoked response testing gives information on the neural integrity in the retrocochlear region to more central areas up to the brainstem.

When the organ of corti is damaged from ototoxic antibiotics or birth malformations and the hair cells are absent even the most powerful hearing aids cannot effectively provide hearing. The cochlear implant can bypass these damaged hair cells by direct stimulation of the nerve fibers in the spiral ganglion to restore hearing.

Histopathology of Sensorineural Hearing Loss

Since electrical stimulation of the cochlea primarily stimulates cochlear neurons grouped within the modiolus (spiral ganglion), successful cochlear implantation necessitates the survival of these neurons. At the recent inauguration of the Ear Unit and the launching of the campaign for the creation of the Institute of Hearing, Balance and Communication Disorders in UP Manila wherein Senator Loren Legarda provided the seed fund of P1 million, the Walter Augustus Lecompte Professor of Otology and Laryngology at Harvard University, Joseph B. Nadol, Jr, MD gave the inaugural lecture. Notably his study

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*Presented in part at the Seminar on Speech and Language Development in the Hearing Impaired Child held at the University of the Philippines Manila, April 27-29, 2000.

**Head, Ear Unit, University of the Philippines Manila-Philippine General Hospital; Section Chief of Otology, Neurotology and Skull Base Surgery, Department of Otolaryngology, UP-PGH Medical Center
on the histopathologic quantification of survival of spiral ganglion cells in the profoundly deaf human provide evidence that 65% of surviving ganglion cells were found between 6 to 22 mm region corresponding to the range of a multichannel electrode (Nadol et al, 1989).

Eddington (1982), cochlear implant director at Harvard University has stated the goal in cochlear implantation which is to develop a system that uses electrical stimulation of the auditory nerve to elicit activity patterns that the brain requires to understand speech and identify environmental sound.

**HOW DOES A COCHLEAR IMPLANT WORK?**

The three main parts of the cochlear implant include the speech processor, the receiver-transmitter and the electrode array.

1. First the speech processor receives and transduces the acoustic speech signal into an electrical representation.
2. The external speech processor transforms the mic output by amplifying, compressing, filtering and shaping the electrical signal into the predetermined pattern of electrical stimulation.
3. The transmitter is placed on the mastoid and provides the interface between the signal from the external speech processor to the implanted components of the CI. The interface is accomplished by transcutaneous radiofrequency transmission to the receiver under the skin coupled by magnetic induction.
4. The receiver which is hermetically sealed to protect the components is placed under the skin on a surgically depressed seat on the skull bone.
5. The electrodes deliver the electrical stimuli to the cochlear neurons and auditory nerve.

The perceptual mechanisms used by the implantee in response to electrical stimulation of the auditory nerve are of course critical. This pertains to how an implantee is able to use these stimuli incorporating auditory, visual, linguistic and non-linguistic information as facilitated by rehabilitation. In the hearing impaired child, the role of teachers and speech as well as auditory verbal therapists and most especially the parents remain to be the most crucial with respect to the success of cochlear implantation.

**COCHLEAR IMPLANTATION IN THE PHILIPPINES**

In November 1997, the first cochlear implantation was performed in the Philippines by a surgical team composed of Prof. Wolfgang Arnold, Dr. Norberto Martínez and the author. Within the same year, on October 1998, the Cochlear Implantation Program was inaugurated at the Philippine General Hospital by then Chancellor Perla Santos-Ocampo, Dean Ramon Arcadio as represented by College Secretary Alberto Roxas, PGH Director Napoleon Apolinario, Department of ENT Chairman Joselito Jamir and Otology Section Chief Generoso Abes. The guest of honor was Professor Dr. Wolfgang Arnold from the Technical University of Munich. The first two patients were post-lingually deafened patients and included an 11 year old grade six honor student from Angeles Pampanga who became deafened by measles and a 26 year old 3-month medical student from Cebu who became profoundly deaf by a congenital inner ear anomaly called LVAS (Large Vestibular Aqueduct Syndrome) a relatively unknown disease in the Philippines first reported in the country only in 1996 (Jugo and Chiong, 1998).

Since then there have been eleven more cochlear implant surgeries independently performed by the author at the Philippine General Hospital from Feb. 1999 onwards. This represents the largest experience on cochlear implantation in the Philippines. Table 1 shows the causes of hearing loss in these patients and the age at implantation.

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Age Implanted</th>
<th>Etiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11:10</td>
<td>Measles</td>
</tr>
<tr>
<td>2</td>
<td>26:5</td>
<td>LVAS</td>
</tr>
<tr>
<td>3*</td>
<td>2:9</td>
<td>Maternal Rubella</td>
</tr>
<tr>
<td>4</td>
<td>3:4</td>
<td>Waardenburg Syndrome</td>
</tr>
<tr>
<td>5</td>
<td>2:10</td>
<td>Maternal Rubella</td>
</tr>
<tr>
<td>6</td>
<td>6:1</td>
<td>Maternal Rubella</td>
</tr>
<tr>
<td>7</td>
<td>7:1</td>
<td>Mondini Dysplasia</td>
</tr>
<tr>
<td>8</td>
<td>13:5</td>
<td>Measles</td>
</tr>
<tr>
<td>9</td>
<td>1:3</td>
<td>Maternal Rubella</td>
</tr>
<tr>
<td>10</td>
<td>47:1</td>
<td>Viral labyrinthitis</td>
</tr>
<tr>
<td>11</td>
<td>60:3</td>
<td>Meningitis</td>
</tr>
<tr>
<td>12</td>
<td>8:1</td>
<td>Meningitis</td>
</tr>
<tr>
<td>13</td>
<td>4:6</td>
<td>Unknown</td>
</tr>
</tbody>
</table>
The MED-EL Combi 40* was the device used in one while the rest had Combi 40+. The last 3 patients were implanted with the Nucleus CI 24M device. The youngest patient was 15 months old when she received her cochlear implant. As her mother knew she had rashes from German measles during her first trimester of pregnancy she was keen on having her baby’s hearing tested during the first three months of life. The baby was diagnosed to have profound deafness very early in life and was fitted with hearing aids at six months of age. As noted in table I, in 25% of the patients the cause of profound deafness could have been preventable by rubella vaccination. This vaccination should be given to all women of childbearing age who may become pregnant. Since the vaccine has live attenuated virus the warning is that one cannot become pregnant within three months of the vaccination. The unfortunate thing is that this vaccination is not available for free at the majority of health centers in the country served by the DOH.

The next most common cause of hearing loss in our series was congenital inner ear malformation (2 and 7) in whom a spiral high resolution CT scanning of the temporal bone was able to establish the etiology of deafness. There have been no complications noted except for one case of extracochlear migration probably due to postoperative trauma. After reinsertion of the electrode no other untoward complications were noted and the patient now benefits tremendously from his implant and is a first honor student at school. There were 2 patients who contracted meningitis one of whom had significant labyrinthine ossification. In the latter a partial drill out of the cochlea was done and eight active electrodes placed over this with muscle to keep the electrodes in place. In the last eleven cases immediate transorbital x-rays confirmed proper placement of electrodes within the cochlear turns.

We have performed pre-operative telemetry testing in two of our post-lingually deafened subjects prior to Combi 40+ implantation. Intraoperative stapedius reflex testing were likewise carried out such that the integrity of the auditory pathways up to the brainstem is already known at the time of surgery. We have routinely taken transorbital x-rays before the patient is wheeled out of the operating room to confirm that the implant is really in place within the cochlea. Lastly we have actively collaborated in a research project with MED-EL of Austria in developing an objective means of determining the most comfortable levels of electrical stimulation so important for pediatric cochlear implantees who are too young to give verbal feedback about the loudness of sounds perceived through their implants. Results of this continuing work were in fact presented at the Cochlear Implant 2000 Conference held in Miami Florida last Feb. 3-5, 2000, at the Symposium of Pediatric Cochlear Implantation in Antwerp last June 2000 and recently in the House Ear Institute sponsored Symposium on Cochlear Implants in Children held in Los Angeles California last March 2001.

CANDIDATE SELECTION PROCESS

Most of our patients have been referred by their therapists and parents because of limited benefit from hearing aids in the hope that cochlear implants would provide a better chance for language acquisition or development. Otolaryngologists referred the four post-lingually deafened subjects to us following the onset of sudden onset profound sensorineural deafness. The 11-year-old boy who became deafened by measles had to contend with hearing aids until a cochlear implant was available. The 26-year-old medical student initially underwent repair of perilymphatic leak that caused sudden deafness in his only hearing ear and after 8 months had cochlear implantation. He has since been able to achieve open set word recognition and could now converse through the telephone on his implanted ear. Our younger patients continue to improve with the help of auditory-verbal training.

Every patient who comes in for possible cochlear implantation has to undergo a thorough medical, audiological and radiologic evaluation.

The medical evaluation seeks to determine other relevant clinical conditions that may preclude implantation or complicate the intra and postoperative course of the patient. It is especially important to know and treat other congenital problems for example other cardiovascular or neurological conditions.

For the audiologic evaluation all previous audiologic work-up are extensively reviewed to determine the
progress and present status of residual hearing. Diagnostic tests in this regard will include an ABR or auditory brainstem response test that looks at the response to broadband clicks from the cochlear nerve and auditory centers in the brain. This is always correlated with the results of behavioural audiometry or visual reinforced audiometry. The reason for this is that the click stimulus during ABR testing corresponds only to the 2000 to 4000 Hz frequency range such that an absent response with maximal stimulation does not say anything about low frequency hearing. The behavioural audiometric evaluation may give information about the low frequency region. Otoacoustic emission (OAE) testing may provide additional information about the outer hair cells at different frequency regions (low to high). The audiologic evaluation is also important to assess whether proper amplification and hearing aid trial has been implemented. In recent years the audiologic criteria for CI have been expanded to include children and adults with severe hearing loss (>70 db pure tone average at 500, 1000 and 2000 Hz).

Radiologic evaluation primarily includes a high resolution CT Scan of the cochlea. There are several objectives in the radiologic evaluation. First, the patency of the cochlear duct through which the electrode array is to be inserted is ascertained. This will be very important especially when meningitis is the cause of deafness as this has the propensity to cause new bone formation and consequently cochlear obliteration or "labyrinthine ossificans". Secondly, the presence of congenital inner ear malformation (Mondini Dysplasia) and the degree of abnormality as well as the number of cochlear turns is determined so that the proper type of implant (regular vs. short electrode) can be prepared. In addition intraoperative complications such as perilymph gushers can be anticipated in some cases of Mondini dysplasias or LVAS. Lastly our protocol includes an MRI evaluation to confirm the presence of cochlear nerve, patency of the membranous labyrinth as well as to rule out other neurologic conditions that may impact on post-implantation recovery and rehabilitation. For example one of our patients was noted on MRI to exhibit areas of demyelination that may explain the global delay and also warrant follow-up MRI examinations. The distinct advantage of the MED-EL Combi 40+ has been its proven safety and compatibility with future MRI examinations that may be needed in certain clinical situations like this. On the other hand with the Nucleus Cochlear Implant 24M device a removable magnet ensures the safety of future MRI studies when indicated.

In addition close communication with other health care professionals that make up the cochlear implant team including the otologist/ surgeon, developmental pediatrician, psychologist, speech or auditory verbal therapist, radiologist and neurologist are invited to attend a pre-implantation conference to discuss all relevant issues regarding perioperative and postoperative care and rehabilitation.

COCHLEAR IMPLANT SURGERY

The goal of surgery is to place the electrode array to closely approximate the residual spiral ganglion cells so that the following can be achieved (Kartush, et al 1994)

1. allow electrical stimulation of the cochlea with as low current levels as possible
2. provide greater specificity of stimulation
3. minimize the extra-cochlear stimulation of facial and vestibular nerves. The former can cause facial twitching while the latter dizziness

Previous studies by the author have shown that despite a substantial survival of vestibular (Scarpa's) ganglion cells that may potentially be stimulated by electrical stimulation in subjects with profound deafness (Chiong, Glynn and Nadol, 1993), very little changes noted on electrooculography prove the safety of multichannel electrode insertion with respect to vestibular function (Chiong, et. al. 1994).
The pertinent surgical steps are outlined below.

1. The hair is shaved and the template for the receiver and processor are placed for a well-planned incision.
2. An inverted J incision in the postauricular area is done after which the flaps are developed to expose the mastoid cortex and skull bone.
3. A limited mastoidectomy with exposure of the incus is performed posteriorly.
4. The bone is drilled in order to seat well the receiver stimulator and for greater stability control holes made for suturing the receiver later.
5. The cochleostomy (opening into the cochlea) is then performed after the facial recess has been dissected to expose the round window inferiorly and stapes superstructure superiorly.
6. The electrode array is inserted gently and the number of electrodes inserted is noted. We then attempt to do intraoperative stapedial reflex testing and telemetry to check for successful stimulation and ascertain implant integrity.
7. The receiver is sutured in place, the ground electrode is placed under the temporalis muscle and antibiotic solution used to irrigate the surgical site prior to closure of the flap.
8. Subcutaneous sutures are placed with close approximation of the edges for good wound healing.
9. An ear bandage is placed (this stays for 48 hours). A portable x-ray machine is wheeled into the operating room to take transorbital x-rays to ascertain proper placement of the implant.

In our preliminary experience with cochlear implantation, we have been greatly encouraged by our initial results. It has sparked a renewed vigor in pursuing excellence in this field and a strong commitment to education with close cooperation with our speech therapists and audiologists. This commitment to provide improved professional hearing health care has resulted in the pioneering Master of Science in Clinical Audiology Program at the University of the Philippines with the first 6 students composed of 4 otolaryngologists, 1 nurse and last but not the least a cochlear implantee. The latter wanted to become a doctor of medicine but driven with the will to understand deafness which has afflicted him from childhood he has now decided to use his restored hearing to study audiology.

We are expecting to expand and improve on these initial gains in the area of improved services to our patients with the acquisition of new equipment for electrocochleography, facial nerve monitoring, in the area of education with the graduation of the first batch of audiology professionals, and in the area of research as we continue to find answers to research questions we find relevant to better understand the results of our own experience with cochlear implants. And with the help of those firmly committed to better care for the hearing impaired, we believe that

"Together we can defeat deafness.

References:

ABACA (Musa textilis) AS AN ALTERNATIVE SUTURE:
A COMPARATIVE STUDY OF TISSUE REACTION AND
TENSILE STRENGTH*

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ROMEO L. VILLARTA, JR., MD***
TERESA LUISA I. GLORIA-CRUZ, MD***
ABEGAYLE MARCHELL M. PEREZ, MD**

Abstract

This experimental study was undertaken to determine the tissue reaction, gross and histologic, in surgically incised wounds, of abaca (Musa textilis) as a suture in comparison with nylon and silk. Tensile strength of each suture was also determined. Twenty (20) Sprague-Dawley rats (approximately 100-130 grams) were anesthetized with ketamine 50 mg/ml, prepared with povidone iodine and placed in supine position. Three (3) 2-cm vertical skin incisions over the abdomen, 1 cm apart, were done and closed with abaca, silk or nylon. Daily wound inspection was done and on the 7th day, the rats were sacrificed. Histologic tissue reaction was determined using the wound histology score adapted from the study done by Mehta. Results were statistically tested with Friedman and showed no significant difference among the three sutures tested. Gross wound healing was described as to skin incision apposition and presence or absence of inflammation. Tensile strength determination was done using the INSTRON model 8852 Biomaterials Testing Model and results were statistically tested with ANOVA. Analysis showed no significant difference among the three sutures. In the study, abaca was shown to be comparable, in terms of tensile strength and tissue reaction, to both silk and nylon. The great abundance and the low cost of the abaca fiber make it a promising cost-effective alternative to commercially available nonabsorbable sutures.

INTRODUCTION

In the 1998 Annual Report in the Department of Otorhinolaryngology at the Philippine General Hospital, the total number of surgical cases done at the outpatient clinic and inpatient ward was 1,225 and 1,787 respectively. All these cases made use of surgical sutures most common of which were silk, nylon and cotton sutures. Sutures are thread-like materials used for approximation of tissues. These may be natural or synthetic; absorbable or non-absorbable; and mono or multifilamentous. The choice largely depends on the requirements for good wound healing and the personal preference of the surgeon.

Sutures play a very important function— to maintain tissue approximation until such time that through the process of healing, the scar attains sufficient tensile strength to prevent dehiscence during normal physiologic activity. In head and neck surgery, the role of sutures carries a more aesthetic role compared to other body parts. Aside from facilitating healing to create strong tissue, it must also result in a cosmetically acceptable and negligible scar.

Some of the more commonly used non-absorbable sutures are silk and nylon. The advantages and disadvantages of each have been extensively described in literature. It has been found that there is no significant difference in the holding power of tissues sutured using any of the abovementioned materials. However, differences in tissue reaction, ease of handling and cost, among others, were noted.

History of the suture dates back to the beginning of life. As stated in the Book of Genesis, “…and they sewed fig leaves together and made themselves aprons.” Eventually man learned that repair by sewing was not limited to objects but may also be used to heal themselves. Documents discovered from ancient Egypt dating back to 3500 and 600

* 1st Place Analytical Research Contest. November 30, 2000, Punta Baluarte, Calatagan, Batangas
** Resident, Department of Otorhinolaryngology, UP-PGH Medical Center.
*** Consultant, Department of Otorhinolaryngology, UP-PGH Medical Center
BC mention sutures made from animal sinews, braided horsehair, leather strips, cotton and fibers made from the bark of the Ashni antaka tree. Even the Egyptian mummies have shown evidence of sutured wounds.

In man's pursuit for the ideal suture, several sources of surgical suture have been used namely animals (hair, feather, intestine), insects, plants (cotton, fiber from the bark of the trees) plastics, ores etc. Locally, ramie and the human scalp hair are among the materials investigated as a suture material.

Abaca or Musa textilis is a fibrous plant native to the Philippines. Its leaf stalks have been harvested and converted to sturdy and affordable cordage material for centuries. Presently, the Philippines remains the world's largest producer of abaca.

The abaca has played several interesting roles in the history of our nation as well as the medical field. During the Second World War (1941-1945) it was used as a suture material by surgeons at the Philippine General Hospital.

Abaca has also been the subject of interest locally by Alonso and Trinidad. In their study, the physical properties (tensile strength, smoothness, color, fraying, etc.) and the tissue reaction of abaca and silk were compared. They concluded that aside from availability and cost, there was no significant difference between abaca and silk.

This study aims to determine the inflammatory reaction after 7 days (to simulate the clinical practice) in the surgically incised wound using abaca and compare it with the two most commonly used non-absorbable sutures - silk and nylon.

The abaca fiber is widely available and inexpensive. If its potential as a suture material can be maximized, the cost of surgery requiring several strands of non-absorbable sutures can be greatly reduced.

**OBJECTIVES**

To determine and compare the tensile strength of abaca, silk and nylon sutures.

To determine and compare surgically incised wounds sutured with abaca, silk and nylon as to histologic tissue reaction.

To describe the gross healing in surgically incised wounds closed with abaca, silk and nylon.

**METHODOLOGY**

**Study Design**

This employs an experimental study (completely randomized design), where all three types of sutures were used to close incised wounds on every subject.

**Experimental Design**

Twenty (20) Sprague-Dawley rats

Three 2-cm vertical abdominal skin incisions; 1-cm. apart

Sutured wounds (one surgeon)

(A- abaca  B- nylon  C-silk)

ABC ACB BCA BAC CAB CBA

Seventh (7th) Day

(Sacrifice of Rats – Removal of Sutures – Tissue Biopsy of wound Incisions)

**Subjects**

Twenty (20) Sprague-Dawley rats (approximately 100-130 grams) were used.
Sutures

Sutures used were silk 4-0, nylon 4-0 and abaca fiber. Silk and nylon, with cutting needles, were obtained from the commercially available individually packaged sutures manufactured by Davis+Geck and Johnson&Johnson, respectively. The abaca fiber was purchased from the local market available as coiled, braided twine. The twine was unwound and each filament manually separated. The fibers used were grossly identical in size or diameter and similar to the other 4-0 sutures used. The abaca fibers were sterilized by soaking in activated diethylene solution commonly used in hospital and clinical setting. Needles used were small, eyed, cutting through which the abaca fiber was looped.

![ABACA twine. Available in the market as coiled, braided twine, cream-white in color](image)

Tensile strength – ratio scale. This is represented by the load (in Newton) and extension at break (in millimeters) and was measured using the INSTRON model 8852 Biomechanical Testing Model at the Integrated Biomaterials Laboratory of the Orthopedic Learning Center at the Philippine General Hospital (Figure 2).

Procedure

Each rat was placed in a supine position, tied, shaved and prepared with povidone iodine antiseptic solution. Three (3) 2-cm vertical skin incisions were done on the abdomen parallel to and equally spaced from each other. The three types of sutures were used and randomly assigned to close the wounds on the abdomen. Order of closure of incision is – left, middle and right. All wounds were closed by the investigator with 4 equally spaced simple interrupted sutures.

![Sprague-Dawley rat with three (3) abdominal skin incisions parallel and equally spaced from each other.](image)

![Surgically incised wounds closed using nylon, abaca and silk at the left, middle and right of the abdomen respectively.](image)
Daily wound inspection was done and healing was assessed as to presence or absence of gross inflammation and tissue approximation. On the 7th day, the rats were sacrificed using ketamine overdose. Wound tissues using a 5 mm margin were obtained from each incision and placed in 10% buffered formaldehyde. Processing was done in the hospitals' surgical pathology laboratory and stained with hematoxylin and eosin (H & E), and viewed under light microscopy by a blinded pathologist.

Inflammation – ordinal scale. This was evaluated using the wound histology score adapted from the study done by Mehta. Wound inflammation is characterized by the presence of inflammatory cells, edema, fibroblast activity, excess capillary proliferation, necrosis and exudation near the wound margin. Six (6) categories were evaluated including giant cells and edema. All of these were assessed by a single pathologist.

The categories used are defined as follows:

Inflammation is described as the presence of neutrophils, lymphocytes and macrophages. Scoring: 0 – none; 1 – minimal; 2 – moderate; 3 – severe.

Fibroplasia was evaluated as to amount of fibroblast and fibrous tissue formation. Scoring: 0 – none; 1– minimal; 2 – moderate; 3 – abundant.

Capillary proliferation correlated with the amount of fibroplasia and the number of capillaries seen in the wound section. Scoring: 0 – none; 1 – minimal; 2 – moderate; 3 – abundant.

Necrosis was defined as the amount of vacuolation, cytolysis, karyorrhexis and karyolysis. Scoring: 0 – none; 1 – minimal; 2 – moderate; 3 – abundant.

Exudation is the amount of cellular debris in tissue. Scoring: 0 – none; 1 – minimal; 2 – moderate; 3 – abundant.

The presence of giant cells and edema were also included as features of wound inflammation. Scoring: 0 – none; 1 – minimal; 2 – moderate; 3 – severe.

**RESULTS**

Outcome variables were analyzed using the statistical package for the Social Sciences 9.05 using one-way ANOVA for load and extension-at-break and the Friedman Ranks test for the other variables utilizing ordinal scale.

<table>
<thead>
<tr>
<th>Type of Suture</th>
<th>Mean Load (Newton)</th>
<th>Mean Extension at Break (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk</td>
<td>6.633</td>
<td>3.412</td>
</tr>
<tr>
<td>Abaca</td>
<td>5.691</td>
<td>1.197</td>
</tr>
<tr>
<td>Nylon</td>
<td>9.479</td>
<td>14.0370</td>
</tr>
</tbody>
</table>

One-way ANOVA p=0.14 One-way ANOVA p=0.000

Tissue Reaction (Figures 5, 6 & 7 – Appendix A)
ABACA (MUSA TEXTILIS)

Tensile Strength

The mean load of nylon, silk and abaca are 9.479N and 5.691N respectively. The mean extension of each suture at break is 14.037mm, 3.412mm and 1.1970mm for nylon, silk and abaca respectively. ANOVA test revealed no significant difference for the mean load among the three (3) types of sutures, but the extension at break was significantly different with nylon possessing the longest extension (Table 1).

Table 2 & 3 Mean Inflammation Scores

Minimum values for silk and abaca was zero (0), including the absence of inflammation in some specimens. All had a maximum value of three (3). There was no statistically significant difference among the 3 sutures in terms of inflammation (p=0.582).

| Table 2. Mean Inflammation Scores Among the 3 Types of Sutures, PGH 2000 |
|-----------------------------|-----------------------------|-----------------------------|
| Type of Suture              | Mean                        | Std. Deviation              |
| Silk                        | 2.1053                      | 1.0485                      |
| Abaca                       | 2.0526                      | 0.7799                      |
| Nylon                       | 2.2632                      | 0.7335                      |

Table 3. Friedman Test for Inflammation

<table>
<thead>
<tr>
<th>Type of Suture</th>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk</td>
<td>1.97</td>
</tr>
<tr>
<td>Abaca</td>
<td>1.87</td>
</tr>
<tr>
<td>Nylon</td>
<td>2.16</td>
</tr>
</tbody>
</table>

P=0.582

Tables 4 & 5. Mean Fibroplasia Scores

Mean fibroplasia scores range from 1.63 to 1.89 with no statistically significant difference (p=0.586).

| Table 4. Mean Fibroplasia Scores Among the 3 Types of Sutures, PGH 2000 |
|-----------------------------|-----------------------------|-----------------------------|
| Type of Suture              | Mean                        | Std. Deviation              |
| Silk                        | 1.6316                      | 1.0116                      |
| Abaca                       | 1.8947                      | 0.9941                      |
| Nylon                       | 1.8421                      | 0.7647                      |
Tables 6 & 7 Mean Necrosis Scores.

There was average necrosis in all suture materials used, with no significant difference.

Table 6. Mean Necrosis Scores Among the 3 Types of Sutures, PGH 2000

<table>
<thead>
<tr>
<th>Type of Suture</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk</td>
<td>1.6842</td>
<td>1.1572</td>
<td>00.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Abaca</td>
<td>1.7895</td>
<td>1.0317</td>
<td>00.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Nylon</td>
<td>1.6842</td>
<td>1.1082</td>
<td>00.00</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Table 7. Friedman Test For Necrosis

<table>
<thead>
<tr>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk</td>
</tr>
<tr>
<td>Abaca</td>
</tr>
<tr>
<td>Nylon</td>
</tr>
</tbody>
</table>

P=0.937

Tables 8 & 9; 10 & 11; 12 & 13. Mean Exudates, Edema and Capillary Proliferation Scores.

The amount of exudates, edema and capillary proliferation among the 3 sutures were relatively minimal to moderate with no statistically significant difference (p=0.705; p=0.970 & p=0.943 respectively).
Table 8. Mean Exudate Scores Among the 3 Types of Sutures, PGH 2000

<table>
<thead>
<tr>
<th>Type of Suture</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk</td>
<td>1.6316</td>
<td>1.1648</td>
<td>0.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Abaca</td>
<td>1.8421</td>
<td>1.2140</td>
<td>0.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Nylon</td>
<td>1.8947</td>
<td>1.1970</td>
<td>0.00</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Table 9. Friedman Test for Exudate

<table>
<thead>
<tr>
<th></th>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk</td>
<td>1.89</td>
</tr>
<tr>
<td>Abaca</td>
<td>1.97</td>
</tr>
<tr>
<td>Nylon</td>
<td>2.13</td>
</tr>
</tbody>
</table>

P=0.705

Table 10. Mean Edema Scores Among the 3 Types of Sutures, PGH 2000

<table>
<thead>
<tr>
<th>Type of Suture</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk</td>
<td>1.5789</td>
<td>1.1213</td>
<td>0.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Abaca</td>
<td>1.6316</td>
<td>1.1161</td>
<td>0.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Nylon</td>
<td>1.5789</td>
<td>1.1698</td>
<td>0.00</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Table 11. Friedman Test for Edema

<table>
<thead>
<tr>
<th></th>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk</td>
<td>2.05</td>
</tr>
<tr>
<td>Abaca</td>
<td>1.97</td>
</tr>
<tr>
<td>Nylon</td>
<td>1.97</td>
</tr>
</tbody>
</table>

P=0.970
Table 12. Mean Capillary Proliferation Score Among The 3 Types Of Sutures, PGH 2000

<table>
<thead>
<tr>
<th>Type of Suture</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk</td>
<td>1.5789</td>
<td>1.0174</td>
<td>0.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Abaca</td>
<td>1.5263</td>
<td>0.7723</td>
<td>0.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Nylon</td>
<td>1.3158</td>
<td>1.0569</td>
<td>0.00</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Table 13. Friedman Test For Capillary Proliferation

<table>
<thead>
<tr>
<th></th>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk</td>
<td>2.05</td>
</tr>
<tr>
<td>Abaca</td>
<td>2.00</td>
</tr>
<tr>
<td>Nylon</td>
<td>1.95</td>
</tr>
</tbody>
</table>

Grossly there was generally good wound healing (no to minimal exudates and good approximation of tissues) for all sutures at all sites, except for six (6) rats. Some incision sites of these rats had exudates involving all three sutures.

**DISCUSSION**

It must be stressed that the first intention of a suture is to heal the wound by first intention. The search for the perfect suture has been going on for years now. Dettinger et. al. described the ideal suture with the following characteristics – tensile strength, tissue reaction, manageability, availability, ease of sterilization and noncarcinogenesis.\(^\text{17}\)

Tensile strength measures the ultimate strength of the material tested, in this case the sutures, to the load of stress applied to it. It is the greatest longitudinal stress a suture can bear without tearing apart.\(^\text{18}\) Although nylon showed the highest value for the tensile strength meaning it has the greatest elasticity and resistance to stress, and abaca the lowest, the ANOVA test revealed no significant difference among the three types of suture. The same findings were found in the other local study.

This shows that abaca has a holding power to the tissue comparable to the much accepted tensile strength of the commonly used nonabsorbable sutures. Thus making tissue approximation stable.

In the study, histologic picture of tissues harvested at the 7\(^{\text{th}}\) post-operative day showed minimal to moderate wound inflammation in all three types of sutures used, similar to the results found in the study done by Alonso and Trinidad, though done in different phases of healing.
In wound healing, the third day is the inflammatory phase with the predominance of PMNs, neutrophils, histiocytes, etc. while the seventh day is in the proliferative phase, fibroblast being the predominant cell. This similarity despite the difference in phases of healing can be due to the different criteria used by the pathologists. Also on the 7th day, though in the proliferative stage of healing, inflammatory cells such as found in the first phase, are still present. Necrosis, exudates and edema are indicators of inflammation, the higher in the other two sutures used. Manageability of the suture during closing of wounds depends on the smoothness of the fiber. In this regard, abaca and nylon are comparable. Being smooth and monofilamentous, both sutures go through the tissue easily. However, silk is not too far behind. Only the light microscopy finding of silk having fraying of fibers and its being multifilamentous made it less smooth than the other two sutures.

Ease of sterilization is also a factor for a suture to be ideal. Silk and nylon are packaged individually and sometimes, as a pack strands, already sterilized. Abaca on the other hand, though not yet commercially available, is easily and conveniently sterilized by soaking in activated dialdehyde, which is commonly used in hospitals and clinics.

Though in the past, the polymers – cellophane, polyethylene and vinyl film – which were used as surgical materials, have all produced a high incidence of sarcomatous change in white mice, silk and nylon have been found to be noncarcinogenic. This specific characteristic has not been studied yet on abaca, however, in literature, natural fibers have proven themselves through the years, to be free of this danger.

All three sutures, silk, nylon and abaca, are readily available in the market but the great abundance of the abaca fiber in our country makes it much more inexpensive compared to the other two sutures. Nylon sells at approximately Php 166 per meter while silk sells at Php 93 per meter. Abaca costs much, much lower, roughly at less than a peso per meter sans the final processing which would surely not amount to that of the other two sutures.
LIMITATIONS OF THE STUDY

Wound healing may be better investigated if observed for a longer period of time. However, in this study the investigator was limited to one week of observation by the cost of acquiring and maintaining the subjects for a longer period.

Other specific properties of the abaca may have been investigated for a more comprehensive comparison with silk and nylon. Properties such as exact diameter of the fiber used, in vivo tensile strength and knot security among others.

CONCLUSION AND RECOMMENDATION

In this study abaca was shown to have tensile strength and tissue reactions comparable to the two more commonly used nonabsorbable surgical sutures – silk and nylon. With its great abundance and very low cost, the potential of this natural fiber as a surgical material would surely be beneficial to all the Filipino surgical patients.

For future studies, we recommend the following:
1. Standardization of the abaca fiber to be used
2. Determination of the tensile strength of each suture in vivo during wound healing;
3. Determination of the effectiveness of sterilization technique applied by doing culture studies
4. Determination of the noncarcinogenesis of abaca
5. Experimental studies using abaca as a surgical suture in human.

REFERENCES
10. Philippine General Hospital Yearbook – 75th Year Anniversary.
ACCURACY OF 512 HERTZ AIR CONDUCTION TEST FOR HEARING SCREENING*

NEIL ALDRINE I. PENAFLOR, MD**
OSCAR HILARIO, MD**
GENEROSO T. ABES, MD, MPH***

Abstract

Objective: To Determine the Accuracy, Sensitivity, Specificity and Likelihood Ratios of 512 Hertz Tuning Fork as a Screening Tool Compared with Diagnostic Audiometer

Design: Cross Sectional Study

Setting: Hearing and Vestibular Science Laboratory of a Tertiary Hospital

Samples: 250 Ears

Results: Demographic data showed 83.2% of patients examined were from the middle age group with male predominance. Otoscopic findings showed 95.2% of the subjects had normal examination. The sensitivity, specificity, and accuracy of tuning fork test compared with diagnostic audiometry was higher at 40db HL than at 30 db HL. The likelihood ratio for positive test was however higher at 30 db but the likelihood ratio for the negative test was lower at the same intensity level. These diagnostic characteristics and predictive values were essentially equivalent to those found using the screening audiometer versus diagnostic audiometer.

Conclusion: The 512Hz tuning fork is an accurate and precise hearing screening tool compared with diagnostic audiometer.

Introduction

The Philippines like other developing countries is in need of a hearing screening instrument that is cheap, familiar, readily available, handy, easy to use yet reliable and accurate. A review of current literature recommends otoacoustic emission (OAE) or impedence audiometry or puretone screening audiometry as the recommended equipments. In most hearing centers, the diagnostic pure tone audiometry is generally used. These instruments are expensive, requires technical know-how, usually dependent on electrical supply, not easily available and delicate. Due to lack of these equipments, there has been an inadequacy of knowledge on the prevalence and distribution of hearing loss in the Philippines. As a consequence, a nationwide integrated hearing screening program has yet to be formulated.

A recent local unpublished study on the prevalence of hearing loss among grade one school children in a rural public school reported that the most common cause of hearing impairment were cerumen and otitis media Both cause conductive hearing loss which typically affect the low frequency sound. A simple and easily available hearing instrument such as the 512 Hz tuning fork that may detect such kind of hearing loss may be useful if its precision and accuracy are proven.

Abes, Penaflor, Hilario and Llanes recently reported on the precision of the 512 hertz tuning fork among normal middle age individuals. The precision of four described procedures was analyzed. It was shown that any of the four described procedures may be used interchangeably without altering the outcome of the test results as far as clinical parameter is concerned.

Of the four procedures however, it was implied that the combined wrist and elbow or the elbow alone procedure with the tine of the fork placed 6 inches away from the external auditory meatus may be most preferred. If proven valid, air conduction test using the 512 hz tuning fork may be a potential hearing screening tool that may be adopted not only in the Philippines but by other less developed countries as well.

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**Resident, Department of Otorhinolaryngology, Manila Doctors Hospital
***Consultant, Department of Otorhinolaryngology, Manila Doctors Hospital
Validity requires that a diagnostic test must not only be precise but accurate as well. This characteristic has not yet been established in the 512 hz air conduction test. This study was carried out to assess this diagnostic characteristic. The specific objectives are:

1. Determine the sensitivity, specificity, accuracy and predictive values of the air conduction test with 512 hz tuning fork compared with diagnostic audiometer among individuals referred for audiometry at the Hearing and Vestibular Science laboratory of the Manila Doctors Hospital.

2. Compute for the 95% confidence interval of the sensitivity, specificity, predictive values and likelihood ratios.

3. Compute for the positive and negative predictive values and likelihood ratios.

4. Compare the change in diagnostic characteristics if intensity level of the gold standard (diagnostic audiogram) is changed from 40db HL to 30db HL.

5. Compare the accuracy of the 512 hertz tuning fork with the screening audiogram at 30db and 40dbHL.

**Methodology**

A. Sampling
Consecutive patients (numbering 125) referred for audiometry at the Hearing and Vestibular Science Laboratory of Manila Doctors Hospital for a period of three months (June - August 1999) were included in this cross sectional study. Demographic data for each patient was taken.

B. Test procedures
All of the tests were done inside an audiometry booth by two separate examiners, a single resident physician and a single technician. The ambient noise (average of 38-db SPL) inside the booth was first determined using a RION® (China) sound level meter before each test begins.

1. Tuning fork test
All tuning fork tests were conducted by a resident physician according to the procedure described by Abes et al. A 6 inches alloy 512 Hertz tuning fork manufactured by Grafo® (USA) was used to test all subjects. The following procedures were carried out in sequence:

   a. The examiner presents a sample of the sound generated by the vibrating tuning fork.

   b. The examinee was instructed to raise the hand whenever he heard the sound.

   c. The examiner stands at the back of the patient to perform the procedure.

   d. The examiner strikes the tine of the fork against the ball of the palm of the opposite hand (Figure 1).

   e. The tine of the vibrating fork was placed about 6 inches away from the external auditory meatus. (Figure 2) Examiner instructs the patient to raise his hand whenever he hears the sound generated by the TF.

   f. The test was done 3 times.

   g. The results of at least two out of the three test were recorded. The result was recorded either as could not hear (Abnormal) or could hear (Normal).
2. Screening audiometry
A portable hearing tester (Siemens SD 10) was used to get the screening audiogram. This was done by the same resident who performed the tuning fork test.

The following procedures were done:
   a. Similar preparations were given to familiarize the examinee to the 500 hz tone signal
   b. As the examinee holds the earphone, a 40db and 30db intensity signals were given (Figure 3.)
   c. The signals were given thrice for each intensity
   d. Responses to at least two of three signals were recorded

3. Pure tone test with diagnostic audiometer
This test was done by an audiologic technician blinded to the results of the preceding tuning fork test and screening audiogram. An Interacoustic AD27 audiometer was used to carry out the test. This audiometer was calibrated weekly.

The following procedures were done:
   a. Similar familiarization procedures were carried out
   b. A 500 Hz, 40 and 30db tone signals were given to the examinee
   c. The examinee separated by a one way mirror from the examiner who was located in an adjacent room pressed a signal button whenever he heard the tone. All the test results were collected, labelled and stored in a computer using Microsoft Excel. The data were analyzed to determine the diagnostic characteristics and predictive values using ear as unit of analysis.

D. Analysis of Data:

1. The results were tabulated in a two by two table and the different characteristics computed (Table 1):

<table>
<thead>
<tr>
<th>Tuning Fork Test</th>
<th>Diagnostic audiogram</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive (Abn) hearing loss</td>
</tr>
<tr>
<td>Positive (Abn) Hearing loss</td>
<td>(a)</td>
</tr>
<tr>
<td>Negative (N) Hearing loss</td>
<td>(c)</td>
</tr>
<tr>
<td>n</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Two by two table
2. Computational definitions of diagnostic characteristics and predictive

a. Sensitivity—measures how well the tuning fork test detects hearing loss as measured by the diagnostic audiogram as the gold standard = a / a+c
b. Specificity—measures how often hearing loss is absent as detected by tuning fork test when the patient is truly normal as detected by the diagnostic audiogram = d / b+d
c. Accuracy—measures the overall accuracy of the diagnostic test = a+d / a+b+c+d
d. Positive predictive value— the posttest probability of having hearing loss when the tuning fork test is abnormal = a / a+b
e. Negative predictive value—the posttest probability of not having hearing loss when the tuning fork test is normal = d / c+d
f. Likelihood ratio for a positive test—expresses the odds of having abnormal result with the tuning fork when hearing loss is truly present on a patient as opposed to a patient without hearing loss = sensitivity / 1-specificity or [a / a+c] / [d / b+d]
g. Likelihood ratio for a negative test—expresses the odds of having normal result with the tuning fork when hearing loss is truly present on a patient as opposed to a patient without hearing loss = 1-sensitivity / specificity or [a / a+c] / [d / b+d]
h. 95% confidence intervals (CI) for sensitivity, specificity, accuracy and predictive values were computed using the formula: 95% CI = sensitivity (specificity or predictive value) ± 1.96 SE
SE = square root of p (1-p) divided by n where, p represents sensitivity or specificity or predictive values, n = number of samples
i. 95% confidence interval for positive likelihood ratio = antilog of log LR ± 1.96 SE
SE = square root of 1/a + 1/b + 1/a+c + 1/b+d

Results

Demographic data showed 83.2% of patients examined were from the middle age group (21-40 years old), whereas sex distribution showed 84.8% were males. Otoscopic findings revealed 95.2% of patients had normal examination. (Figures 1a-c.)

The values obtained from 250 ears (125 patients) and the corresponding computations of the different characteristics and predictions shown in Table 2-b were computed from the numerical values shown in Table 2-a. Note the increase in number of subjects who could hear the tuning
fork as the puretone intensity signal used was increased (175 to 222). Conversely, there was a decrease in the number of subjects who could not hear the tuning fork (24 to 21).

<table>
<thead>
<tr>
<th>Tuning Fork Test</th>
<th>Diagnostic audiogram</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Could not hear (Abn)</td>
</tr>
<tr>
<td></td>
<td>40dbHL 30dbHL</td>
</tr>
<tr>
<td>Could not hear (AbN)</td>
<td>21 24</td>
</tr>
<tr>
<td>Could hear (N)</td>
<td>2 49</td>
</tr>
</tbody>
</table>

Table 2a—Tuning fork versus Diagnostic audiogram

The change in sensitivity, positive predictive value and likelihood ratios are demonstrated in Table 2b and Table 2c. As the diagnostic criteria for hearing loss becomes more strict (40 to 30db) the prevalence of hearing loss becomes lower. Correspondingly, the sensitivity and the positive predictive value of the tuning fork to detect hearing loss (as indicated by the pure tone audiogram) become lower. On the other hand, the likelihood of detecting hearing loss for a positive test becomes higher (30 to 33).

<table>
<thead>
<tr>
<th>Characteristics/Predictions of 512 Hz tuning fork</th>
<th>Diagnostic audiogram at &gt; or = 40db (%)</th>
<th>95% Confidence Interval at ≥40db</th>
<th>Diagnostic audiogram at &gt; or = 30db (%)</th>
<th>95% Confidence Interval at ≥30db</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>91</td>
<td>90.65-91.35</td>
<td>33</td>
<td>32.42-33.58</td>
</tr>
<tr>
<td>Specificity</td>
<td>97</td>
<td>96.8-97.19</td>
<td>98</td>
<td>97.8-98.17</td>
</tr>
<tr>
<td>Accuracy</td>
<td>97</td>
<td>96.8-97.19</td>
<td>79</td>
<td>79.5-80.49</td>
</tr>
<tr>
<td>Positive predictive Value</td>
<td>81</td>
<td>80.5-81.49</td>
<td>92</td>
<td>91.67-92.33</td>
</tr>
<tr>
<td>Negative predictive Value</td>
<td>99</td>
<td>98.8-99.12</td>
<td>78</td>
<td>77.49-78.51</td>
</tr>
<tr>
<td>Likelihood Ratio for Positive Test</td>
<td>30</td>
<td>10.38-86.48</td>
<td>33</td>
<td>7.46-148</td>
</tr>
<tr>
<td>Likelihood Ratio for Negative Test</td>
<td>0.93</td>
<td>-1.59-1.38</td>
<td>0.68</td>
<td>-2.44-1.13</td>
</tr>
</tbody>
</table>

Table 2b—Computations for the different characteristics and predictions
The change in the tabulated results in Table 3-a follows the same pattern as that of Table 2-a. As the criterion for hearing loss became more strict by using 30db HL instead of 40db HE, the number of subjects detected as abnormal by the tuning fork became higher (21 to 29). On the contrary, less subjects were categorized as normal (214 to 173). The change in sensitivity, positive predictive value and likelihood ratios shown in Table 3-b correspond to the changes noted in Table 2-b.

<table>
<thead>
<tr>
<th>Screening audiogram</th>
<th>Diagnostic audiogram</th>
<th>Could not hear (Abn)</th>
<th>Could hear (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40db</td>
<td>30db</td>
<td>40db</td>
</tr>
<tr>
<td>Could not hear (Abn)</td>
<td>21</td>
<td>29</td>
<td>2</td>
</tr>
<tr>
<td>Could hear (N)</td>
<td>13</td>
<td>44</td>
<td>214</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Characteristic/Predictions of 512hz tuning fork</th>
<th>95% Confidence Interval at ≥ 40db (%)</th>
<th>95% Confidence Interval at ≥ 30db (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>91</td>
<td>90.65-91.35</td>
</tr>
<tr>
<td>Specificity</td>
<td>94</td>
<td>93-70-94.30</td>
</tr>
<tr>
<td>Accuracy</td>
<td>94</td>
<td>93.70-94.30</td>
</tr>
<tr>
<td>Positive predictive Value</td>
<td>62</td>
<td>61.41-62.59</td>
</tr>
<tr>
<td>Negative predictive Value</td>
<td>99</td>
<td>98.88-99.12</td>
</tr>
<tr>
<td>Likelihood Ratio for Positive Test</td>
<td>1.51</td>
<td>17.26</td>
</tr>
<tr>
<td>Likelihood Ratio for Negative Test</td>
<td>0.09</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Table 3b-Values of characteristics and predictions for screening audiogram

Discussion

With the diagnostic audiogram as the gold standard, high specificity (97%; p=0.00) of the 512 hz tuning fork indicates that we can practically rule in hearing loss whenever the tuning fork is not heard (Table 2-b). This is in concordance with the positive predictive value of 81% which means that among those with abnormal test on the tuning fork (could not hear), the probability of having hearing loss is 8 out of 10.

Using the likelihood ratio for a positive test, we can better translate the results clinically by saying that the odds of having an abnormal test by tuning fork is 30 times higher with a patient who indeed
has hearing loss than with somebody with normal hearing. This can even be better understood if we use the obtained likelihood ratio for a negative test of 0.93. This means that the odds of having a patient with hearing loss when the tuning fork result is normal (could hear) is only 1/10. This means further that this probability is far less than what can be obtained by 50-50 chance which gives an equivalent likelihood ratio of 1.

The high sensitivity of the tuning fork (91%; p=0.00) means that 9 out of 10 of those with abnormal tuning fork result have indeed hearing loss. Those with normal tuning fork result (could hear) can be labeled normal indeed (NPV=99%) since the false negative result is practically nil. Such characteristic will avoid mislabelling normal individuals as hearing impaired that may result to unwarranted concerns. The negligible likelihood ratio for a negative test of 0.1 further supports this claim.

The high specificity therefore translates that whenever the tuning fork test result is positive or abnormal, we can confidently rule in hearing loss ("SpPIN"). On the other hand, when the tuning fork test is normal (can hear), we can confidently rule out hearing loss because of high sensitivity ("SnNOUT"). The high sensitivity, high specificity and high positive predictive value are attributes required of a good test for screening program.

The above results only apply if the intensity level to designate normal and abnormal hearing level is 40db hearing level. If 30db hearing level is used, (Table 2-b) the specificity remains high but the sensitivity becomes much lower. This means that with a positive test (could not hear), we can still confidently rule in hearing loss. However the lower sensitivity implies high false negative rate. This means that an examinee who fails to hear the tuning fork must not be easily labeled abnormal. The negative predictive value of 80% indicates that among those with negative test (could hear the tuning fork), 2 out of 10 may still be mislabeled as normal when in fact they may indeed have hearing loss. Nevertheless the study indicates that the 512 Hz tuning fork has higher accuracy detecting moderate but less accurate in detecting mild hearing loss (97% versus 80%). Hence, we must be careful in observing those whom we suspect of having hearing loss if he registers a negative result so as not to miss a disorder. He may after all be having mild hearing loss which was not detected during the first test. This highlights the importance of having a cheap, simple and available screening instrument that can be used repeatedly so as to validate a previous negative (normal) result!

The above mentioned characteristics and predictive values speak of the accuracy of the tuning fork as a hearing screening tool. Comparing these with those obtained with the screening audiometer versus the same gold standard (Table 3-b) clearly indicates that it may indeed be a rational substitute for screening audiogram. The diagnostic characteristics were essentially equivalent (Table 4). In interpreting these data however, bias could not be totally disregarded since while there were two blind evaluators for the gold standard (diagnostic audiogram), there was only one evaluator for both the tuning fork and screening audiogram.

Although the results obtained in this study look promising as far as the search for a simple, accurate, precise and affordable hearing screening tool is concerned, one must not immediately conclude that it may be used for all types of
population sample and by anybody. The study samples belonged to the middle age group. The results may be valid for children with conductive hearing loss due to impacted wax or otitis media. Only the 500 Hz frequency was evaluated in this study. Thus the results may apply only to those disease entities that may cause low frequency loss such as external or middle ear disorder. Early presbycusis manifested as high frequency loss may not be detected. Hence studies on the appropriate target population must be conducted.

The examiner in this study was a resident physician who was well acquainted with the instrument done in an ideal test environment. If this is to be adopted at the community level, there should be corresponding training to ensure the precision of the examiner and corresponding accuracy of the test results. The samples used were referrals from doctors hence, the positive predictive value could be overestimated. Disease prevalence is known to be higher in referral centers compared to the community.10

In a real community setting where prevalence of hearing loss is generally lower, the corresponding positive predictive value is also lower. Since the ultimate utility of this study entails its usefulness when done by local community examiners, it is quite important that the results of this study be validated by studies performed in various population groups and carried out by actual local community workers.

### Summary and Conclusion

Two hundred fifty ears of one hundred twenty five consecutive patients were included in this cross sectional study to determine the accuracy of the 512 hertz tuning fork versus pure tone audiogram (Diagnostic Audiometry). Results showed that tuning fork test has high specificity, sensitivity and accuracy and that the estimate of the true population values for these characteristics were precise. These diagnostic characteristics together with computed predictive values were almost equivalent with those obtained with screening audiometry. These parameters indicate that the 512 Hertz tuning fork is an accurate hearing screening tool. Due to the limitations regarding subject selection and environmental factors, it is recommended that the results of this test be validated by studies done among different populations at the community level.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>512Hz Tuning Fork</th>
<th>Screening audiogram</th>
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<tbody>
<tr>
<td></td>
<td>40db</td>
<td>30db</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>91</td>
<td>33</td>
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<td>97</td>
<td>98</td>
</tr>
<tr>
<td>Accuracy</td>
<td>97</td>
<td>80</td>
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Table 4-Comparison of the diagnostic characteristics between 512 Hz tuning fork and screening audiometer
REFERENCES

PIG BRONCHUS
*A Case Report of a Tracheobronchial Anomaly*

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Abstract

Objective:

To present a case of pig bronchus (syn. Tracheal bronchus), specifically:

1. to present the clinical profile of the case
2. to discuss the clinical data in relation to the reports in medical literature
3. to increase awareness for this uncommon but clinically significant entity.

Design: Case Report
Setting: Tertiary Government Hospital
Patient: Thirty-one-year-old female with supraclavicular mass
Results:

A thirty-one-year-old female presented with cough and right supraclavicular mass of one month duration. Fine-needle aspiration biopsy of the supraclavicular mass revealed metastatic poorly differentiated carcinoma. On triple endoscopy, the right upper lobe bronchus arose from the right tracheal wall. This tracheobronchial anomaly (termed the tracheal bronchus or "pig" bronchus) was further demonstrated on Chest X-ray, CT Scan, and MRI. An incidental finding was a mass at the branching of the pig bronchus. Biopsy of this bronchial mass revealed squamous metaplasia. The patient underwent chemotherapy and radiotherapy.

Conclusion:

Pig bronchus in a thirty-one-year-old female is presented. Its incidence, clinical presentation, embryology, diagnosis and management are discussed.

Most individuals with pig bronchus are asymptomatic and do not need any treatment. Their mere presence, however, may be of considerable clinical significance in certain cases. It is important, therefore, for physicians to keep this airway anomaly in mind when managing patients with possible associated medical or surgical problems.

INTRODUCTION

In humans, the bronchus of the right upper lobe arises from the right main bronchus. In pigs, however, the bronchus of the right upper lobe, the "pig bronchus," arises directly from the right tracheal wall. The pig bronchus, also called the tracheal bronchus, is normal in pigs but is considered anomalous in humans (Figure 1).

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Figure 1. Illustration of the Normal Bronchus and Pig Bronchus
The pig bronchus is an uncommon anatomic variant in humans. Its incidence has been cited to range from 0.1 to 5% (Barat et al., 1987). During bronchoscopy, its incidence has been reported at 2% (McLaughlin et al., 1985).

Most cases are asymptomatic and are detected incidentally during bronchoscopy or radiologic procedures (Kim et al., 1998). In some cases, however, tracheal bronchus may present with respiratory tract symptoms: recurrent pneumonia, persistent atelectasis, or even stridor (McLaughlin et al., 1985).

This report aims to increase awareness of this uncommon entity. For nonsurgical physicians, suspicion for this entity may solve some cases of recurrent right upper lobe infections. For anesthesiologists, an awareness of this entity may prevent iatrogenic atelectasis from an intubation that compromises this bronchus. For thoracovascular surgeons and bronchoscopists, awareness of the pig bronchus may improve preoperative and intraoperative decision making. For all physicians, whether surgical or nonsurgical, an awareness of this entity might just spare one more life.

**THE CASE**

This was a 31 year-old Filipino female with a right supraclavicular mass of one-month duration (Figure 2). This was associated with dry cough, right supraclavicular pain radiating to the right scapular area, and occasional difficulty of breathing. Fine needle aspiration biopsy of the supraclavicular mass revealed poorly differentiated carcinoma, metastatic to lymph node (Figure 3).

**Figure 3. Microscopic Appearance of the Fine Needle Aspiration Biopsy Specimen: Poorly-Differentiated Carcinoma, Metastatic to Lymph Node.**

On physical examination, a 2 x 1.5 x 1.5 cm firm nontender fixed mass was noted at the right supraclavicular area.

Subsequent flexible bronchoscopy showed a bronchus arising from the right tracheal wall about 1 cm above the carina (Figure 4). Three branchings were noted to arise from this bronchus.

**Figure 4. Bronchoscopic View of the Pig Bronchus. A bronchus (arrowhead) arises from the right tracheal wall approximately 1 cm above the carina.**

Beyond the carina, only 2 secondary bronchi arose from the right main bronchus. The left main bronchus was unremarkable.
The above findings indicate that the right upper lobe bronchus (with the apical, anterior, and posterior branchings) arose from the right tracheal wall while the right middle and lower lobe bronchi arose from the right main bronchus. This aberrant location of the right upper lobe bronchus is called a tracheal ("pig") bronchus.

An incidental finding in this tracheal bronchus was a grayish friable mass at the branching of the apical and posterior lobes (Figure 5). Punch biopsy showed squamous metaplasia.

![Figure 5. On bronchoscopy; a mass partially obstructs the lumen of the pig bronchus at its branching. M=mass; B=bronchial branching.](image)

Rigid esophagoscopy and rigid nasopharyngoscopy revealed normal findings. Chest x-ray, thoracic CT scan, and thoracic MRI showed the presence of a bronchus arising from the right tracheal wall supplying the right upper lobe (Figures 6 & 7). Furthermore, pulmonary nodularities were also noted.

![Figure 6. Chest radiography showed a bronchus (arrow head) arising from the right tracheal wall.](image)

![Figure 7. On MRI, a bronchus (arrow head) is seen arising from the tracheal wall.](image)

The patient underwent chemotherapy and radiotherapy. However, she died 4 months after the diagnosis.

**DISCUSSION**

The case presented was a thirty-one-year old female with tracheal bronchus. This tracheobronchial anomaly is well-described in foreign medical literature with no reported cases locally.

This case report is unusual in 3 respects: first, the anomalous location of the right upper lobe bronchus (at the tracheal wall); second, the presence of a tumor in the branchings of this tracheal bronchus; and third, the presence of a metastatic carcinoma to a supraclavicular lymph node.

**Demography**

There are no patterns reported on the sex incidence of the pig bronchus. Of the 18 cases reported by Mclaughlin et al (1985), 11 were boys and 7 were girls. Although one author cited that pig bronchus is more predominant in males (Barat & Konrad, 1987), this was not supported with data.

A pig bronchus may be detected at any age: from the newborn period to old age. Cases have been reported from age 0-54 months (Mclaughlin et al, 1985) up to 80 years old (Harris, 1968; Kim et al, 1998).
The true incidence of pig bronchus is unknown because most cases are asymptomatic and are discovered incidentally during bronchoscopy and radiologic procedures done for some other primary disease. The present case was also detected incidentally during the bronchoscopy and imaging studies done for the metastatic carcinoma of unknown primary.

The reported incidence of the pig bronchus varies. Mclaughlin et al. (1985) reported a 2% (8/412) incidence among pediatric patients who underwent bronchoscopy. Other authors cite the following incidence: 0.1% - 3% (Ikeno et al., 1996), 5 out of 1,200 bronchograms (Landing & Dixon, 1979), 0.1% - 0.6% (Laforet et al., 1962), and 3% in 1,000 consecutive bronchograms (Le Roux, 1962).

**Signs and Symptoms**

Although most cases are asymptomatic, pathologies of the pig bronchus produce signs and symptoms referable to the right upper lobe. The present case had cough and occasional dyspnea. Seventeen out of the 18 cases reported by McLaughlin et al. (1985) had respiratory tract symptoms: recurrent pneumonia in nine, stridor in six, and respiratory distress in two. Recurrent episodes of pneumonia in the right upper lobe may suggest pathologies in the pig bronchus (Barat & Konrad, 1987; Kim et al., 1998). Furthermore, in Down’s Syndrome, recurrent pneumonia may be due to this anatomic anomaly rather than to recurrent aspiration (Barat & Konrad, 1987).

The statement of O’Sullivan (1998) that “once identified, the pig bronchus has no particular significance” is true in majority of asymptomatic cases. However, during surgeries, the pig bronchus is of great importance. Firstly, endotracheal intubation into the pig bronchus may cause overdistention of the right upper lobe and subsequent pneumothorax. Moreover, intubation blocking the pig bronchus may cause atelectasis of the right upper lobe (Barat & Konrad, 1987; O’Sullivan et al., 1998). Carefully planned intubation is thus indicated in diagnosed cases of pig bronchus (Ikeno et al., 1996). Secondly, during lung transplants, a pig bronchus may cause technical difficulty. The thoracic surgeon should be prepared for procedures suited for these anatomic variants (Magee et al., 1994). Thirdly, for the young bronchoscopist, the pig bronchus may be mistaken for a stenotic right main bronchus.

The pig bronchus may be associated with other congenital abnormalities, although this was not the case in the present report. Mclaughlin (1985) reports that 14/18 (78%) of cases had other congenital abnormalities involving the respiratory, gastrointestinal, and musculoskeletal systems. Down’s syndrome, patent ductus arteriosus, tracheoesophageal fistula, and abnormal pulmonary vasculature are among the abnormalities reported (O’Sullivan et al., 1998; Barat & Konrad, 1987; Harris, 1958; Wells et al., 1988).

Aside from the pig bronchus, the present case presented with a premalignant tumor at the branching of the pig bronchus: squamous metaplasia. It is not certain whether lung parenchyma supplied by the tracheal bronchus is inherently more susceptible to disease (Laforet et al., 1966; Kim et al., 1998). However, there are cited cases of tumors (adenomas and carcinomas) arising from the pig bronchus (Harris, 1958; Kim et al., 1998).

The bronchial tumor of the present case was small enough to have caused only cough and occasional dyspnea. Larger tumors arising from the pig bronchus may manifest with symptoms of a right upper or apical lobe pneumonia or atelectasis. These symptoms, however, are relatively milder and have a more delayed presentation than tumors arising in a normal right upper lobe. This may be explained by the independent “take-off” of the pig bronchus. Tumors arising from a normal right upper lobe bronchus may manifest symptoms earlier due to extension to the right main bronchus and subsequent obstruction of the whole right lung (Figure 8).

**Etiology/Embryogenesis**

The respiratory primordium is first recognized at 24 days as a thickening of the median ventral wall of the foregut. At 27 days, this becomes a pear-shaped
Embryologically, the displacement of bronchi occurs at 34-40 days age of gestation. Bronchial buds may originate at atypical sites from as high as the trachea to as low as the middle lobe position. The etiology of this displacement is not clear but they may be due to minor environmental factors of intrauterine life (Boyden, 1955). (Figure 9)

Figure 9. Varying locations of the right upper lobe bronchus. It can be located as high as the trachea or as low as the middle lobe position.

Diagnosis

The tracheobronchial anomaly in the present case was diagnosed both by bronchoscopy and imaging studies.

Bronchoscopic findings are pathognomonic. The pig bronchus is almost invariably located at the right tracheal wall (Mclaughlin et al., 1985; Barat & Konrad, 1987). The majority are located 2 cm or less above the carina, the closest being 0.2 cm but could be as high as 6 cm.

Diagnostic radiology mainly consists of bronchography, CT scan, and occasionally plain radiography. (Barat & Konrad, 1987; Ikeno et al., 1996).

There are various classifications of the pig bronchus in the literature (Harris, 1958; Landing & Dixon, 1979; Mclaughlin et al., 1985; Laforet et al., 1962). This paper adopts the classification presented by Mclaughlin, who categorized pig bronchi into the following:

bulge at the end of the laryngotracheal groove. At 28 days, this bulge has given rise to the right and left lung buds. As it elongates, the respiratory portion of the gut becomes separated from the esophageal portion. At 30 days, the lung buds have elongated into the primary bronchi or primary lung sacs. At 32 days, the five lobar bronchi appear as monopodial outgrowths of the primary bronchi. Between the 34th and 36th days, the lobar bronchi branch until all segmental bronchi are present. Between the 36th and 38th days, the segmental buds appear. All segmental bronchi are represented by the 40th day (Roshe, 1965).
1. displaced segmental (a pig bronchus supplying the right apical lobe)
2. displaced lobar (a pig bronchus supplying the whole right upper lobe)
3. supernumerary apical (a pig bronchus supplying the right apical lobe in addition to the normally-placed right apical bronchus)
4. supernumerary lobar bronchus (a pig bronchus supplying the right upper lobe in addition to the normally-placed right upper lobe bronchus). (Figure 10.)

The most common type is the displaced lobar bronchus, as in the case presented (a tracheal bronchus with 3 tertiary bronchi).

Management

An incidental finding of pig bronchus in an asymptomatic patient (i.e. during radiologic studies done for other primary pathologies) does not warrant any treatment. Knowledge of its existence, however, may alert the physician for possible associated anomalies or potential respiratory problems.

Whenever a pig bronchus is associated with recurrent right upper lobe disease, excision of the bronchus and its corresponding lobe is the treatment of choice (Barat, 1987).

CONCLUSION

A pig bronchus in a thirty-one-year-old female with a bronchial mass was presented. Its incidence, clinical presentation, embryology, diagnosis and management were discussed.

Most individuals with pig bronchus are asymptomatic and do not need any treatment. However, their mere presence may be of considerable clinical significance in certain cases. It is important, therefore, for physicians to keep this airway anomaly in mind when managing patients with possible associated medical or surgical problems. An awareness of this uncommon but clinically significant condition might just spell the difference between life and death.

Figure 10. Classifications of Pig Bronchus (Mclaughlin et al, 1987).
REFERENCES