OTOLARYNGOLOGY

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ISSN 2470-4059 Open Journal http://dx.doi.org/10.17140/OTLOJ-3-133

Systematic Review

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Volume 3 : Issue 1
Article Ref. #: 1000OTLOJ3133

Article History
Received: October 26th, 2016
Accepted: November 18th, 2016
Published: November 22nd, 2016

Citation
Ramadan O. Petrous Apex cerebrospinal fluid (CSF) leak: A Review Article. *Otolaryngol Open J*. 2016; 3(1): 1-8. doi: 10.17140/OTLOJ-3-133

Petrous Apex Cerebrospinal Fluid (CSF) Leak: A Review Article

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ABSTRACT

Objective: The objective of this study was to present a review article about petrous apex cerebrospinal fluid (CSF) leak.
Data Sources: Published English-language literatures in PubMed and Google Scholar.
Review Methods: PubMed and Google Scholar were systematically searched using search terms: petrous, apex, cerebrospinal and leak. Temporal, bone, cerebrospinal and leak.
Study Selection: We included studies about petrous apex CSF Leak.
Results: Seventeen studies were included in this study. The results showed that 72% of patients are adult and 28% of patients are children. Meningocele is the most common cause of petrous apex CSF leak in pediatric patients, while iatrogenic trauma is the most common cause in adult patients. Seventy-seven percentage of pediatric patients have active leak, while 96% of adult patients have active leak. Nose is the most common site of CSF leak in both adult and pediatric patients. Sixty-six percentage of pediatric patients have meningitis while only 20% of adults have meningitis. Most cases need surgical procedure. Eleven percentage of pediatric patients have a recurrence, while 20% of adult patients have a recurrence.
Conclusion: Petrous apex is a rare location for CSF leak.

KEYWORDS: Middle fossa approach; Transmastoid approach; Meningocele; Gorham-stout; Spontaneous CSF leak.

ABBREVIATIONS: CSF: Cerebrospinal fluid; MFA: Middle Fossa Approach; TM: Tramsmastoid; TMA: Transmastoid approach; BMI: Body Mass Index; PAC: Cephalocele of petrous apex; CT: Computed Tomography; MRI: Magnetic Resonance Imaging; Anti-IL6: Anti-Interleukin-6; Anti-VEGF: Anti-Vascular Endothelial Growth Factor; ET: Eustachian Tube.

INTRODUCTION

Cerebrospinal fluid leak (CSF) from an intracranial source is rare, as it is a life-threatening condition that can have difficulties in localization, diagnosis, and management. CSF leaks from the petrous apex are extremely rare, as only few cases are reported in the world literature. Surgery of petrous apex area has potentially high morbidity rate due to complex anatomy. Multiple surgical approaches have been developed for reaching petrous apex region (subtemporal, transtemporal, endoscopic transnasal), all of them aiming to increase the anatomic exposure, reduce the complication rates, and result in high successful treatment. Each approach has its advantages and disadvantages. We in this review article discuss about the English literatures of petrous apex CSF leak.[1]

MATERIAL AND METHODS

Literature review was conducted using PubMed (MEDLINE) and Google Scholar for English articles. The following keywords were used: petrous; apex; cerebrospinal and leak temporal, bone, cerebrospinal and leak.

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Inclusion Criteria

All petrous apex CSF leak articles published after 1990 were included in the study.

RESULTS

Sixteen studies about petrous apex CSF leak were available in PubMed (MEDLINE) and Google Scholar in English literature (Table 1).

Demographs

There were 33 patients of age ranged from 5 to 71. There were 9 pediatric patients, 6 patients of them were male 66%, while the other 3 patients were female 33%. There were 24 adult patients, 12 patients of them were male 50% and 12 patients were female 50% (Chart 1).

	Age Sex	Symptoms	Etiology	Treatment	Recurrence	leakage
Kou et al[1]	61 F	Rhinorrhea B/l hearing loss recurrent meningitis	Left cephalocele spontaneous CSF leak	First approach MFA sealed with bone wax and covered with fascia second operation MFA The meningocele was reduced and the defect was plugged with an abdominal fat graft and fibrin glue.	Yes	Nose
Warade et al[2]	26 M	CSF Rhinorrhea	Right Meninogcele	Extradural MFA the defect packed with fat, covered with fascia lata graft and fibrin glue.	No	Nose
Morimoto et al[3]	11 F	Vertigo, Headache, Pulsatile tinnitus. Hearing loss	Right Gorham-stout	Extradural MFA packed with superficial temporal fascia, periosteum flap, and sealed with fibrin glue. Medical treatment; interferon-alpha 2b	No	Cervical Pharyngeal area
Grant et al[4]	53 F	Recurrent meningitis	Left Iatrogenic Acoustic neuroma	First operation: an excision of the mastoid-cutaneous fistula tract, and the wound was closed with a temporoparietal fascia flap. Second operation: modified transcochlear petrous apex. The distal eustachian tube was obstructed with Proplast and abdominal fat placed in the cavity.	Yes	Nose Postauricular CSF fistula
	56 M	Profuse right-sided rhinorrhea, Meningitis	Right iatrogenic	Conservative therapy. First:translabyrinthine obliteration of the mastoid with an abdominal fat graft. Head of the malleus was packed into the Eustachian tube. Second; transcochlear obliteration of the petrous apex, Proplast was packed into the tube and fat used to obliterate the petrous apex.	Yes	Nose
	28 M	CSf otorrhea Heaing loss profound	Right Trauma Acoustic neuroma	Lumbar drainage rest Ventriculoperitoneal shunt. First oberation: This was managed with a radical mastoidectomy and eustachian tube obliteration, Second: Transcochlear approach obliteration was done with fat. The eustachian tube was occluded with Proplast.	Yes	Middle ear
	57 F	CSF rhinorrhea	Right iatrogenic Acoustic neuroma	The CSF leak did not resolve with bed rest and lumbar drainage. She underwent a right-sided transcochlear packed with abdominal fat. Proplast was packed into the medial end of the eustachian tube and abdominal fat packed into the cavity.	No	Nose
Motojima et al[5]	6 F	Recurrent Meningitis	Right meningocele	MFA stuffed soft tissue and fascia in air cells with fibrin glue for repair	No	Nose
Dzaman et al[6]	60 M	Otorhinorrhea Profound hearing.	Right choleasteoma	Combined MFA and Trans-mastoid. Temporal fascia graft, fibrin glue, and collagen patch tachoSil treated the fistula and CSF leak, obliteration of the eustachian tubal orifice, closure of the external auditory canal, and obliteration of the middle ear and mastoid clefts were essential in this procedure. Bony defects were repaired through the use of an acrylic mass.	No	Nose
Cushing et al[7]	12 M	Headache Nausea Vomiting Hearing loss Facial palsy	Right Gorham-stout	Tympanomastoidectomy, eustachian tube plugging, middle ear and mastoid obliteration with fat	No	surgical site zygmotic root, TMJ area

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Isaacson et al[8]	55 F	Otalgia Meningitis Hearing loss	Right cephalocele	Middle fossa approach packing wax, fascia and muscle	No	Not active
Danner et al[9]	49 F	Otorhinorrhea	Latrogenic right Meningioma	Lumbar drain rest Transient	No	Nose
Sekhar et al[10]	37M	CSF Leak	Latrogenic Mhordoma	Lumbar drain	No	One throw wound
	42 F	CSF Leak	Latrogenic Meningioma	Lumbar drain, rest reoperation packing multilayer, fascia, obliteration with fat, ET plugging, bone graft for defect, fibrin glue for sealing	No	Nine throw middle ear
	53 M	CSF Leak Meningitis	Latrogenic Chordoma	Lumbar drain, rest peritoneal shunt (palliative)	No	One
	46 F	CSF Leak	Latrogenic Meningioma	Lumbar drain, rest reoperation packing: multilayer, fascia, obliteration with fat, ET plugging, bone graft for defect, fibrin glue for sealing	No	Through external ear one throw
	33 F	CSF Leak	Latrogenic Chordoma	Lumbar drain, rest nose repacking foreman flap for sphenoid	No	Sphenoid
	58 F	CSF Leak	Latrogenic Meningioma	Lumbar drain	No	
	64 F	CSF Leak	Latrogenic Meningioma	Lumbar drain, rest reoperation packing multilayer, fascia, obliteration with fat, ET plugging, bone graft for defect, fibrin glue for sealing	No	
	35 M	CSF Leak	Latrogenic Chondrosarcoma	Lumbar drain wound	No	
	43 M	CSF Leak	Latrogenic Meningioma	Lumbar drain, rest reoperation packing multilayer, fascia, obliteration with fat, ET plugging, bone graft for defect, fibrin glue for sealing	No	
	46 F	CSF Leak	Latrogenic Aneurysm	Lumbar drain, rest reoperation packing multilayer, fascia, obliteration with fat, ET plugging, bone graft for defect, fibrin glue for sealing	No	
	40 F	CSF Leak meningitis	Latrogenic Meningioma	Lumbar drain packing peritoneal shunt	No	
	38 F	CSF Leak	Latrogenic Meningioma	Lumbar drain	No	
Ota et al[11]	34 M	Rhinorrhea	Right iatrogenic	Lumbar drain trans-petrosal multilayer, HAC Hydroxiappetiate for packing then fiber glue then piece of dura then fat then fiber glue	No	Nose
	59 F	Rhinorrhea	Right iatrogenic	Lumbar drain trans-petrosal multilayer, HAC Hydroxiappetiate for packing then fiber glue then piece of dura then fat then fiber glue	No	Nose
	32 M	Rhinorrhea	Left iatrogenic	Lumbar drain Trans=petrosal multilayer, HAC hydroxiappetiate for packing then fiber glue then piece of dura then fat then fiber glue	No	Nose middle ear
Hervey-Jumper et al[12]	14 M	Recurrent meningitis Headache	Bilateral meningoceles (larger on the left)	MFA Pericranium patch and fat graft, dural repair, and, fibrin glue. Second operation endoscopic trans nasal approach	Yes	Retro pharyngeal
Pross et al[13]	5 F	Recurrent meningitis Facial and abduces palsy Sudden hearing loss rhinorrhea Chiari	Left meningocele	Extradural MFA, Multilayer defect coverage the herniated brain and dura were resected and the dura was closed primarily. The petrous apex was packed with gelfoam as support for temporalis fascia graft underlay. The defect was covered with another piece of temporalis fascia, calvarial bone graft, and synthetic dural substitute	No	Nose
Oyama et al[14]	71 M	Rhinorrhea	Right Iatrogenic cholesteatoma	Lumbar drainage, rest MFA muscle free flap	No	Nose

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Moore et al[15]	5 M	RIGHT CSF leak	Right meningocele	MFA the dura was closed primarily. The petrous apex was packed with gelfoam as support for temporalis fascia graft underlay. The defect was covered with another piece of temporalis fascia, calvarial bone graft, and synthetic dural substitute	No	Nose
Schick et al[16]	12 M	CSF LEAK Meningitis	Right meningocele	Endoscopic transnasal approach perichondrium obtained from the left ear. As a second layer, the prepared mucosal flap was used to cover the site of repair	No	Nose
Mulcahy et al[17]	6 M	Meningitis	Right meningocele	MFA, TM The dura was closed primarily. The petrous apex was packed with gelfoam as support for temporalis fascia graft underlay. The defect was covered with another piece of temporalis fascia, calvarial bone graft, and synthetic dural substitute	No	Not active
	9 M	Meningitis	Right meningocele	MFA, TM The dura was closed primarily. The petrous apex was packed with gelfoam as support for temporalis fascia graft underlay. The defect was covered with another piece of temporalis fascia, calvarial bone graft, and synthetic dural substitute	No	Not active

Table 1: Article in our study.

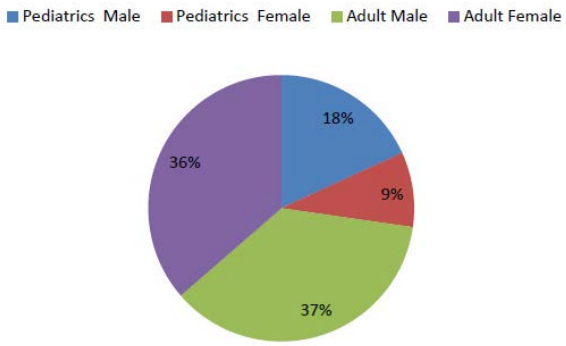

Chart 1: Petrous apex CSF leak demographs.

Side of CSF leak: Seven pediatrics patients had CSF leak from right side 77%, one from left side 11%, and one had B/L CSF leak 11%. Nine adult patients had CSF leak from right side 75%, while the other 3 patients had CSF leak from left 25%.

CSF Leak Site

Pediatrics patients: Four patients had CSF leak from nose, 3 patients had CSF leak in petrous apex surrounding areas (neck, retropharyngeal, and zygomatic area), while the other 2 patients had no active CSF leak (Chart 2).

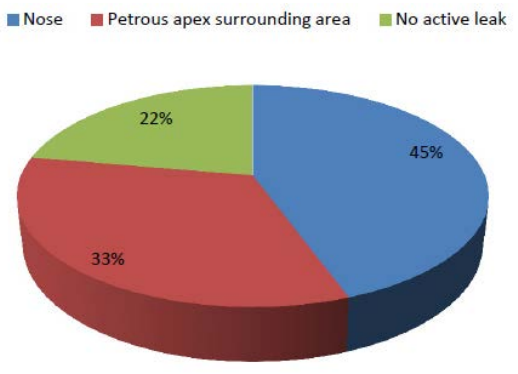

Chart 2: Petrous apex CSL leak sit in pediatrics.

Adult patients: Twelve patients had CSF leak from nose, 10 patients had CSF leak from middle ear, 2 patients had CSF leak from the surgical wound, one from external auditory canal, and one had no active CSF leak (Chart 3).

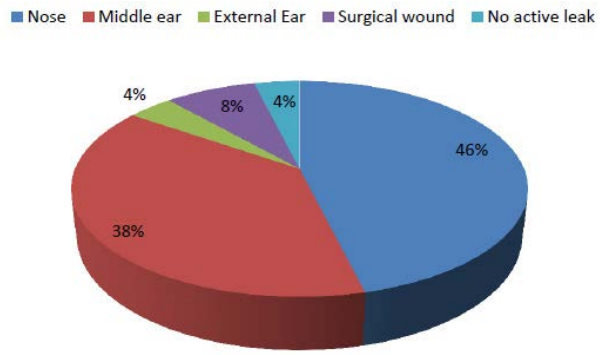

Chart 3: Petrous apex CSF leak site in adult patients.

Etiology

Pediatric patients: Seventy-seven percentage of patients had meningocele (the most common cause in pediatric patient), while the 22% patient had Gorham-stout syndrome which is lympho-vascular proliferation malformation of bones (Chart 4).

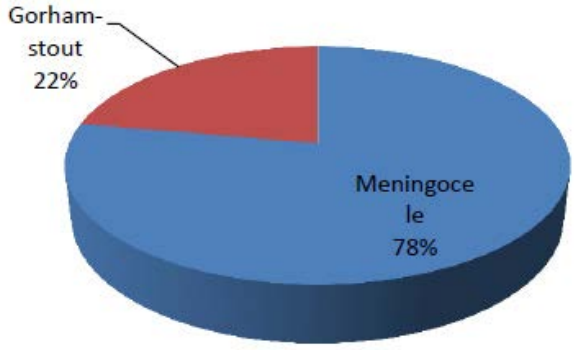

Chart 4: Etiology in pediatric patients.

Adult patients: Eighty-three percentage of patients had iatro-

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genic trauma (the most common cause in adult patients), 8% of patients had cephalcele, 4% of patients had external trauma, and 4% had spontaneous CSF leak (Chart 5).

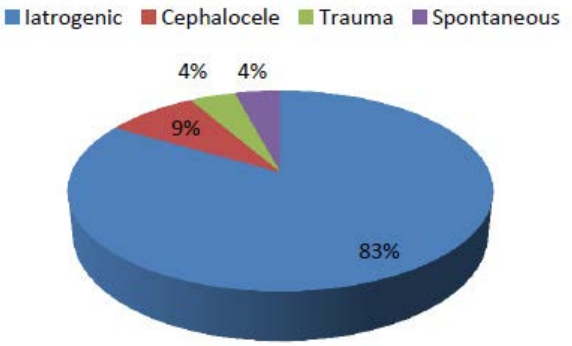

Chart 5: Etiology in adult patient.

Associated Symptoms

Pediatrics: Seventy-seven percentage of patients had active CSF leak, 66% of patients had history of meningitis, 33% of patients had headache, and 33% of patients had hearing loss (cranial 8 nerve involvement) (Chart 6).

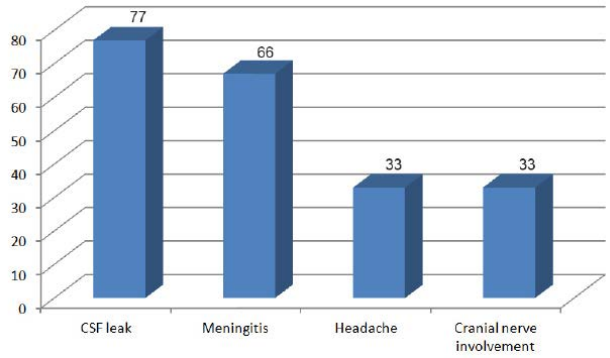

Chart 6: Associated symptoms percentage in pediatric patients.

Adults: Ninety-six percentage of patients had active CSF leak, 20% of patients had history of meningitis, 8% of patients had headache, and 16% of patients had cranial nerve palsy (CN VI, CN VII and CN VIII) (Chart 7).

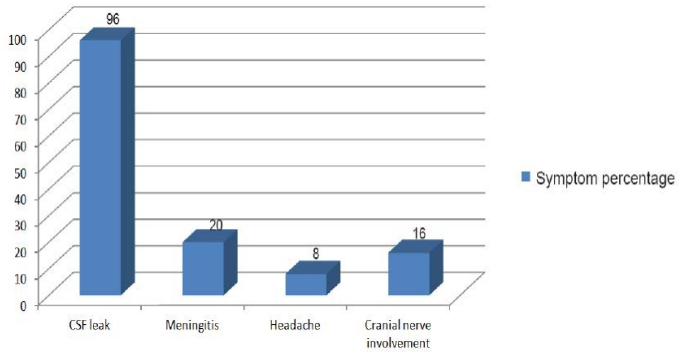

Chart 7: Associated symptoms percentage in adult patient.

Treatment

Pediatrics: Five patients had middle fossa approach (MFA), one of them had a recurrence and had another endoscopic trans-nasal approach to repair the CSF leak. Two patients had a combined MFA and trams-mastoid (TM), one had transmastoid approach (TMA) and one patient had trans-nasal approach (Chart 8).

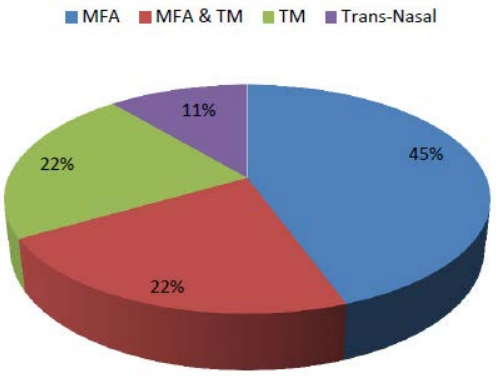

Chart 8: Treatment approaches in pediatric patients.

Adult: Twenty-one patients had conservative management and CSF leak continued in 17 patients of them, 2 patients had lumboperitoneal shunt, 6 patients had re-exploration of surgical site with repacking, 4 patients had MFA and one of them had recurrence and treated with MFA approach, and 6 patients had trans-petrosal approach and 3 patients of them had recurrence and treated with tras-petrosal approach (Chart 9).

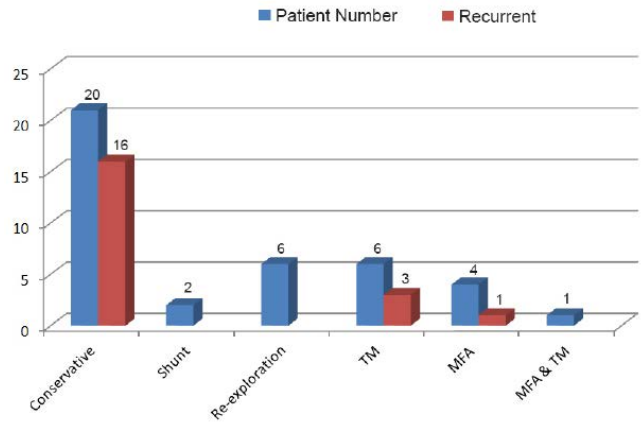

Chart 9: Treatment approaches in adult patients.

Fistula Repair

Five patients had multilayer repair using fascia, fibrin glue, fat packing to obliterate middle ear, Eustachian tube (ET) plugging and bone graft to support defect. Five patients had multilayer repair using primary dura closure, fascia, gelfom packing, and ET pulgging and synthetic dura. Five patients had a fascia for duraplasty, ET plugging, fat obliteration and fibrin glue. Three patients had multilayer repair using hydroxyapatite packing, fiber glue, fascia and fat. Three cases had fascia for durplasty, patched

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with fascia and fibrin glue for sealing. One patient had only fascia and bon wax, 2 had free flab. One patient had perichondrium graft and nasal mucosal flap. One had fascia and packing with muscle and bone wax sealed by fibrin glue. One patient had fistula removal and packed with fascia (Table 2).

Prognosis

There was one recurrent case in pediatrics group 11%, and 4 recurrent cases in adult group 16% (Chart 10).

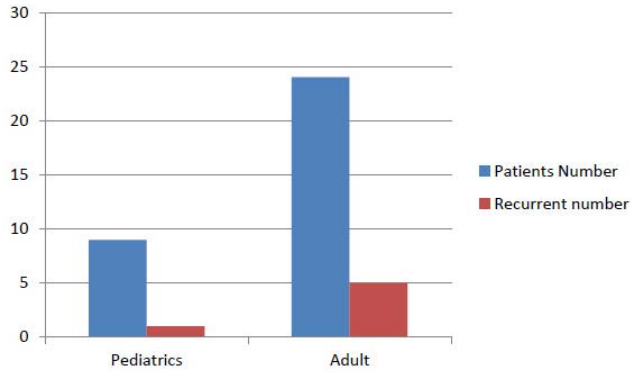

Chart 10: Recurrent cases.

DISCUSSION

Cerebrospinal fluid (CSF) leak develops when there is a fistula between the subarachnoid space and the aerated areas of the temporal bone. Spontaneous leaks are commonly misdiagnosed as chronic serous otitis media. Generally, the diagnosis is done by the presence of β2-transferrin in the middle ear and nasal fluid. Meningitis is the most significant complication of persistent CSF otorrhea or rhinorrhea. Common causes of petrous apex CSF leaks include iatrogenic injury, congenital malformation, meningocele, trauma, and choleasteoma and spontaneous CSF leak 1.

Pelosi et al[18] reported 14 cases of temporal bone CSF leak, one of them was from petrous apex area. Patients with spontaneous CSF leaks are usually females aged 40-60 with body mass index (BMI) greater than 30. They should also be evaluated for other problems associated with idiopathic intracranial hypertension (IIH) (ophthalmologic, neurologic, and empty sella). We should suspect this disease in patients with multiple meningitis and we review their imaging even if they have a negative β2 transferrin.

Cephalocele of petrous apex (PAC) is a rare lesion, it extends into the petrous apex from Meckel's cave. It is usually asymptomatic in adults. CSF leak of PAC has only been seen in children. PAC might make up of either one or all 3 layers of the meninges. It could be congenital or acquired. The symptoms of PAC are CSF rhinorrhea, otorrhea, trigeminal neuralgia, headache and recurrent episodes of meningitis in children. Chronic pulsations against the thin anterior wall of a pneumatized petrous apex and raised intracranial pressure leading to dehiscence, herniation of meninges and CSF leak through weak points in the petrous apex. These lesions may be either unilateral or bilateral. Magnetic resonance imaging (MRI) has a key role in diagnosing these lesions as they follow CSF signal on all sequences and that these directly communicate with Meckel's cave. Treatment is surgical removal for symptomatic cases and surgical approach whether MFA or tranpetrosal is determined by patients hearing ability (Figures 1 and 2).[2]

Gorham-Stout syndrome is a lymphovascular proliferation of unknown etiology, lymph vessels usually do not penetrate the temporal bone. Computed tomography (CT) findings are helpful to assess the extent of bone destruction, while T2-weighted MRI can show the extent of abnormal lymphovascular proliferation. Contrast lymphangiography can be used to find exactly the site of leakage. Meningitis secondary to CSF leakage is a life-threatening complication of Gorham-Stout syndrome. Surgical treatment does not prevent progression of the disease, but it is effective. Gorham-Stout osteolytic lesions should be removed minimally and carefully since the leakage increases in some cases after biopsy. Anti-interleukin-6 (Anti-IL6) receptor antibody and anti-vascular endothelial growth factor (anti-VEGF), antibodies (bivacizumab) that decrease angiogenesis, bisphosphonates that decrease osteoclast activity and bone resorption, interferon propranolol can be used to treat this disease (Figure 3).[3]

Iatrogenic trauma is the most common cause of petrous apex CSF leak in our study, it is usually seen in pneumatized petrous apex that have anatomic pathway between the petrous apex and the medial ET. It is recommended to close ET and obliterate middle ear and mastoid cavity when the patient has pneumatized

	Multilayer fascia oblitartion with fat, ET plugging, bone graft, fibrin glue for sealing	Multilayer Fascia HAT and fat for packing, ET plugging, sealing with fibrin glue	Multilayer, primary dura closure, fascia, gelfom packing, ET bulging, synthetic dura	Fascia for durplasty, patched fascia and fibrin glue for sealing	One patient had only fascia and bon wax	Free flab	Perichondrium graft and nasal mucosal flap	Fascia for duraplasty, packing with muscle and bone wax, sealed by fibrin glue	Fascia for duraplasty ET plugging, fat obliteration, fibrin glue sealing	Fistula removal, and packing with fascia
Patients	5	3	4	3	1	2	1	1	5	1
Recurrence	0	0	0	1	1	0	0	0	2	1

Table 2: Fistula repair.

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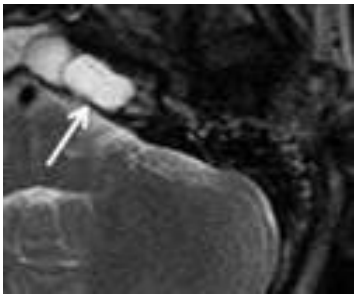

Figure 1: Meningocele axial T2-weighted note that the lesions demonstrate a signal identical to that of CSF, and are located in the petrous apex.

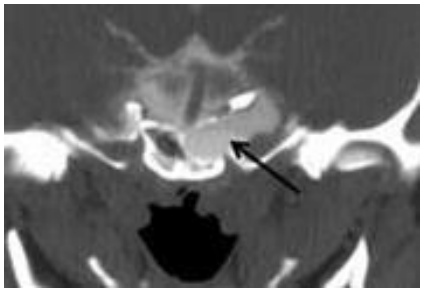

Figure 2: Coronal CT scans performed after intrathecal administration of contrast material, illustrating left petrous apex meningocel with leakage of contrast into the sphenoid sinus.

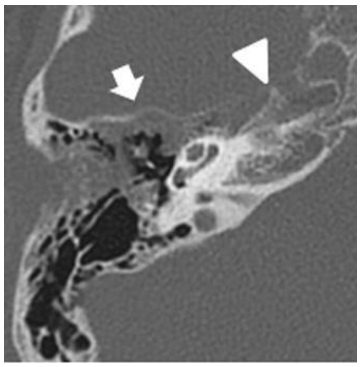

Figure 3: Non-contrast axial CT of the temporal bone, showing partially lytic lesion in the right mastoid air cell (arrow) and petrous apex (arrow head). Note fluid in the mastoid air cells and at the apex of the petrous temporal bone.

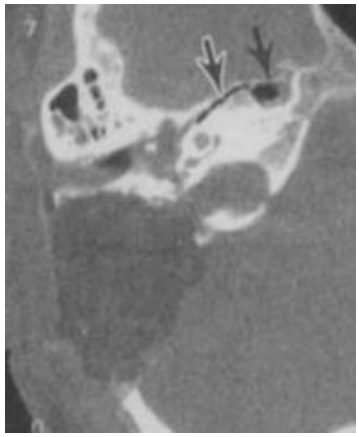

Figure 4: Axial CT scan showing air and defect in the petrous apex.

petrous apex with that abnormal pathway. Surgical repacking using multilayered obliteration technique is recommended for the cases that do not respond to conservative treatments (Figure 4).[4]

Petrosal cholesteatoma is rare entity, it may be primary or acquired in the origin. Primary congenital cholesteatoma arise from embryonary ectodermal inclusions but the pathogenesis is not clear. Congenital cholesteatoma may be asymptomatic or manifest as a conductive hearing loss, otalgia, vertigo and facial palsy. CSF rhinorrhea is extremely rare manifestation of cholesteatoma. Treatment is surgery *via* MFA or transpetrosal depending on hearing abilities in symptomatic cases, a multilayered obliteration technique in which artificial and autologous materials are combined is the best modality of treatment with the highest rate of success.[6]

CONCLUSION

Petrous apex CSF leak is more common in adults, iatrogenic trauma is the most common cause in adult patients while meningocele is the most common cause in pediatrics, CSF leak is more from right side. Meningitis, cranial nerves involvement and headache can also be associated with CSF leak. Multilayer fistula repair is least likely to recurre (Table 3).

	Pediatrics	Adults
Percentage	27%	73%
The most common cause	Meningocele	Iatrogenic
Sex	M<F	M=F
Side	Right<Left	Right<Left
Active leak	77%	96%
Meningitis	66%	20%
Treatment	Surgery	Conservative management then Surgery
Recurrence	11%	16%

Table 3: Petrous apex CSF leak conclusion.

ISSN 2470-4059 http://dx.doi.org/10.17140/OTLOJ-3-133

ACKNOWLEDGEMENT

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CONFLICTS OF INTEREST

The author declared that he has no conflicts of interest.

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