Observational Study

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Clinical outcomes of revision radical mastoidectomy surgeries to dry ears

A retrospective study

Ly Li, MM[a,b], Shusheng Gong, MD[b], Jing Xie, MD[b], Chaoshan Wang, MM[a,*]

Abstract

This study retrospectively investigated the reasons for failure to dry the ear after primary radical mastoidectomy for chronic otitis media. In this retrospective study, we analyzed the main causes of dry ear failure in 43 patients (46 ears) who underwent radical mastoidectomy. We found that inadequate exposure of the mastoid cavity, incomplete removal of pathological tissues, and poor drainage of the surgical cavity were the main reasons for failure of radical mastoidectomy. Lesions in the tympanic ostium of the eustachian tube and incorrect selection of surgical techniques could also cause dry ear failure. Revision surgery based on preoperative temporal bone computed tomography and intraoperative surgical findings could achieve dry ear in 100% of cases and no complications were observed. In patients who underwent tympanoplasty, there was a significant postoperative decrease in the decibel hearing level for the air conduction threshold and air–bone gap ($P < .05$). Based on the reasons for failure, the corresponding treatment was undertaken to achieve dry ears during revision surgery.

Abbreviations: ABG = air–bone gap, CT = computed tomography, CWD = canal wall down, CWU = canal wall up, dBHL = decibel hearing level.

Keywords: dry ear, otitis media, revision surgery, temporal bone CT, tympanoplasty

1. Introduction

Radical mastoidectomy is the typical treatment for chronic suppurative otitis media. Chronic suppurative otitis media with cholesteatoma in the middle ear, in which the middle ear cleft is chronically infected, is accompanied by conductive hearing loss and tympanic membrane defects. Surgery aims to eliminate pathological tissues, achieve a dry ear, and restore or reconstruct the function of the middle ear. Dry ear is considered to be one of the most objective measurements in radical mastoidectomy.[1,2] However, this has not been achieved in patients with recurrent cholesteatoma or persistent purulent discharge in the mastoid cavity postoperatively. In such cases, revision radical mastoidectomy is required. Revision surgery aims to safely achieve a dry ear and eradicate the disease.

Canal wall up (CWU) and canal wall down (CWD) are the most common surgical techniques used in mastoidectomy. In CWU, both the external canal wall and middle ear volume are preserved and the physiological position of the tympanic membrane is maintained. Some studies have reported that CWU had better functional results than CWD[3] but there were no significant differences in the self-perceived quality of life of patients who underwent CWU versus those who underwent CWD.[4,5] After CWU, a higher risk of cholesteatoma and revision surgery recurrence was reported than after CWD.[6,7] Tympanoplasty, which is classified into 5 types (type I–type V) according to the Wullstein classification, is frequently performed during a mastoidectomy. Onofre et al reported that preoperative temporal bone computed tomography (CT) was helpful in determining the presence of soft tissue in the antrum and the addition of mastoidectomy in type I tympanoplasty.[8] High-resolution thin-slice CT scans are important for selecting clinical surgical types and improving the surgical success rates.

In this retrospective cohort study, 43 patients (46 ears) underwent revision radical mastoidectomy. Temporal bone CT results and intraoperative findings were analyzed to identify factors associated with dry ear failure after primary mastoidectomy, and the key points in revision mastoidectomy were discussed.

2. Methods

2.1. Ethical statement

This study was approved by the Institutional Ethics and Research Committee of Beijing Friendship Hospital Affiliated with the Capital University of Medical Sciences.

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

[a] Department of Otorhinolaryngology, Shunyi Hospital, Beijing, China, [b] Department of Otorhinolaryngology Head and Neck Surgery, Beijing Friendship Hospital Affiliated to Captial University of Medical Sciences, Beijing, China.

** Correspondence: Chaoshan Wang, Department of Otorhinolaryngology, Shunyi Hospital, Beijing 101300, China (e-mail: wangchaoshan2009@163.com).*

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2.2. Participants

The data of 43 patients (46 ears) who underwent revision mastoidectomies at the Beijing Friendship Hospital between 2018 and 2020 were retrospectively reviewed. All patients presented with dry ear failure 7 to 18 months after the primary mastoidectomy surgery.

2.3. Surgical technique

All 43 patients (46 ears) were offered preoperative temporal bone CT scans (0.6-mm thick), pure-tone audiometry, eustachian tube function evaluation, and electronic otoscopy. Revision mastoidectomy was performed under an ear microscope under general anesthesia. Operative data were recorded, including the primary surgical technique, state of the ossicles, size and location of the main pathology (cholesteatoma or granulation tissue), materials used for obliteration, extent of disease recurrence, and complications after the primary surgery.

2.4. Outcome

After surgery, the patients were treated with antibiotics for 3 days, and the surgical cavity was filled with iodoform gauze for 2 weeks. After the iodoform gauze was removed, the dressing in the operating cavity was changed under a microscope once every 1 to 2 weeks. Ofloxacin ear drops were administered for 1 to 2 weeks. The time of dry ear after reoperation and pre and postoperative audiograms were recorded. Follow-ups were scheduled for 6 to 18 months after surgery.

2.5. Statistical analysis

The statistical significance of the average hearing thresholds for air conduction and air–bone conduction pre- and post-surgery was assessed using paired-sample *t* tests using SPSS software (version 20.0; IBM Corp., Armonk, NY). Differences were considered statistically significant at *P* values of <.05.

3. Results

3.1. Patient demographics

The average age of the patients was 42 years (range, 23–67 years) and the male/female ratio was 0.79 (19 males and 24 females). Of these 43 patients (46 ears), 30 (32 ears) had cholesteatoma in the middle ear and 13 (14 ears) had chronic otitis media. During primary mastoidectomy, 34 ears underwent CWD, 12 ears underwent CWU, 33 ears underwent tympanoplasty (type II), 9 ears underwent tympanoplasty (type III), 17 ears underwent cavoplasty, and 5 ears underwent external auditory canal reconstruction. The surgical techniques used in the primary mastoidectomy of 46 ears are summarized in Table 1.

3.2. Preoperative CT and intraoperative findings

Preoperative temporal bone CT scans were performed in all patients, which provided sufficient video information for surgery. In revision surgery, 27 ears (58.6%) had recurrent cholesteatoma and 19 ears (41.4%) had granulation tissue in the surgical cavity. Intraoperative findings and preoperative temporal bone CT scans were used to identify the common causes of dry ear failure during the primary surgery (Table 2) (Fig. 1).

The most common problems were inadequate opening of the operative cavity and incomplete removal of the pathological tissue during the initial surgery. Inadequate opening of the mastoid tip air cells (76.1%) was most commonly found in the primary surgery, followed by the sinodural angle (65.2%), perilabyrinthine and retrofacial air cells (47.8%), anterior epitympanic recess (43.5%), and posterior tympanum (41.3%). Cholesteatoma and granulation were frequently found in the mastoid tip cells (34 ears, 73.9%), sinodural angle (26 ears, 56.5%), sinus tympani (23 ears, 50.0%), and anterior attic recess (20 ears, 43.5%) during revision surgery. Insufficient drainage of the surgical cavity was found in our cases, which was usually caused by a high facial ridge (24 ears, 52.2%) and stenotic external auditory canal (29 ears, 63.0%). Lesions in the tympanic ostium of the eustachian tube were observed in 16 ears. In addition, the failure of 5 ears to dry in the primary surgery was caused by the selection of an incorrect surgical technique (Fig. 2).

3.3. Revision mastoidectomy techniques

In revision mastoidectomy, all 46 ears underwent modified radical mastoidectomy: 40 ears (86.9%) underwent type II or type III tympanoplasty, 38 ears (82.6%) underwent conchaplasty, and 8 ears (17.4%) underwent ear canal posterior wall

Table 1

Summary of surgical techniques in primary and revision mastoidectomy.

Surgical techniques for primary mastoidectomy	No. of ears
CWD and tympanoplasty (type II)	16
CWU, tympanoplasty (type II), and cavoplasty	10
CWU and tympanoplasty (type II)	2
CWD, tympanoplasty (type II), and external auditory canal reconstruction	5
CWD and tympanoplasty (type III)	6
CWD, tympanoplasty (type III), and cavoplasty	3
CWD and cavoplasty	4

CWD = canal wall down, CWU = canal wall up.

Table 2

Main problems found in preoperative temporal bone CT scans and during revision surgery.

Finding	No. of ears	Percentage (%)
Inadequate opening of the operative cavity		
Mastoid tip air cells	35	76.1
Sinodural angle	30	65.2
Perilabyrinthine and retrofacial air cells	22	47.8
Anterior epitympanic recess	20	43.5
Posterior tympanum	19	41.3
Residual cholesteatoma and granulation		
Mastoid tip cell	34	73.9
Sinodural angle	26	56.5
Sinus tympani	23	50.0
Anterior attic recess	20	43.5
Insufficient drainage of the surgical cavity		
Stenotic external ear canal	29	63.0
High facial crest	24	52.2
Lesions in the tympanic ostium of the eustachian tube		
Inflammatory mucosal edema	9	19.6
Granulation or cholesteatoma tissue obstruction	6	13.0
Selection of incorrect surgical technique	5	10.9

CT = computed tomography.

reconstruction. In 6 ears (13.0%), mucosal epithelialization was found in the middle ear cavity and tympanic cavity of the eustachian tube, and the tympanic cavity was no longer an air cavity. Therefore, only a radical mastoidectomy and conchaplasty were performed. The surgical techniques used in the 46 ears are listed in Table 3.

3.4. Dry ear rates and pure-tone averages

All 43 patients (46 ears) achieved dry ears within 4 to 8 weeks after surgery, with an average time to dry ears of 5 weeks. Pre and postoperative audiograms were available for 40 ears that had undergone tympanoplasty. Hearing was evaluated using a pure-tone auditory test 3 months postoperatively. Differences in hearing thresholds for bone conduction, air conduction, and air–bone gaps (ABGs) before and after surgery were compared between the type II and type III tympanoplasty groups (Table 4). The decibel hearing level (dBHL) for bone conduction, air conduction, and ABG was defined as the pure-tone mean at 0.5, 1, 2, and 4 kHz.

In the type II tympanoplasty group (29 ears), the mean dBHL in preoperative and postoperative bone conduction was 16.8 ± 5.1 and 17.1 ± 3.7, respectively, whereas, in the type III tympanoplasty group (11 ears), the mean dBHL in preoperative and postoperative bone conduction was 17.3 ± 4.2 and 17.2 ± 5.1, respectively. The difference between the mean dBHL in preoperative and postoperative bone conduction in both the type II (P = .6017) and type III tympanoplasty groups (P = .5236) was not statistically significant.

The average dBHL in the preoperative and postoperative air conduction threshold was 54.3 ± 10.1 and 39.2 ± 9.3, respectively, in the type II tympanoplasty group and 51.9 ± 10.7 and 42.2 ± 11.1 in the type III tympanoplasty group. Significant differences between preoperative and postoperative air conduction were found in both the type II (P = .0278) and type III (P = .0367) tympanoplasty groups.

The difference between the average dBHL in the pre and postoperative ABGs was also compared. The average postoperative ABGs were 22.1 ± 9.4 (type II) and 25.0 ± 4.4 (type III), which were significantly smaller than the preoperative ABGs of 37.5 ± 3.6 (type II, P = .0047) and 34.6 ± 8.5 (type III, P = .0032), respectively.

3.5. Follow-up and recurrence

All patients were followed up for 6 to 18 months. The operative cavities in all the ears were epithelialized. The tympanic membrane was intact after tympanoplasty and there was no pus or hyperplastic granulation in the surgical cavities. No cholesteatoma recurrence has been observed.

4. Discussion

In this retrospective cohort study, dry ears were observed in 43 patients (46 ears) who had undergone revision radical mastoidectomy. Temporal bone CT and intraoperative findings suggested 4 causes of dry ear failure in primary mastoidectomies.

In this study, we found that the most common cause of dry ear failure in primary mastoidectomy was that the surgical cavity was not fully opened, and the lesion was not completely removed (90.6%). As the anatomical structure of the middle ear mastoid is complex, residual diseased tissue in the tympanic sinus, anterior epitympanic recess, sinus meningeal angle, and mastoid air cells may lead to dry ear failure and cholesteatoma recurrence after mastoidectomy. Abnormal middle ear mastoid structures, such as advancement of the sigmoid sinus, lower meningeal floor of the middle cranial fossa, and elevation of the jugular bulb, make it difficult to contour the mastoid and completely remove the lesions. In this study, mastoid tip air cells (76.1%), sinodural angle (65.2%), perilabyrinthine and retrofacial air cells (47.8%), anterior epitympanic recess (43.5%), and posterior tympanum (41.3%) were the most common sites of residual pathological tissue.

We found that no excision of the head of the malleus intraoperatively was a major cause of residual lesions in the anterior

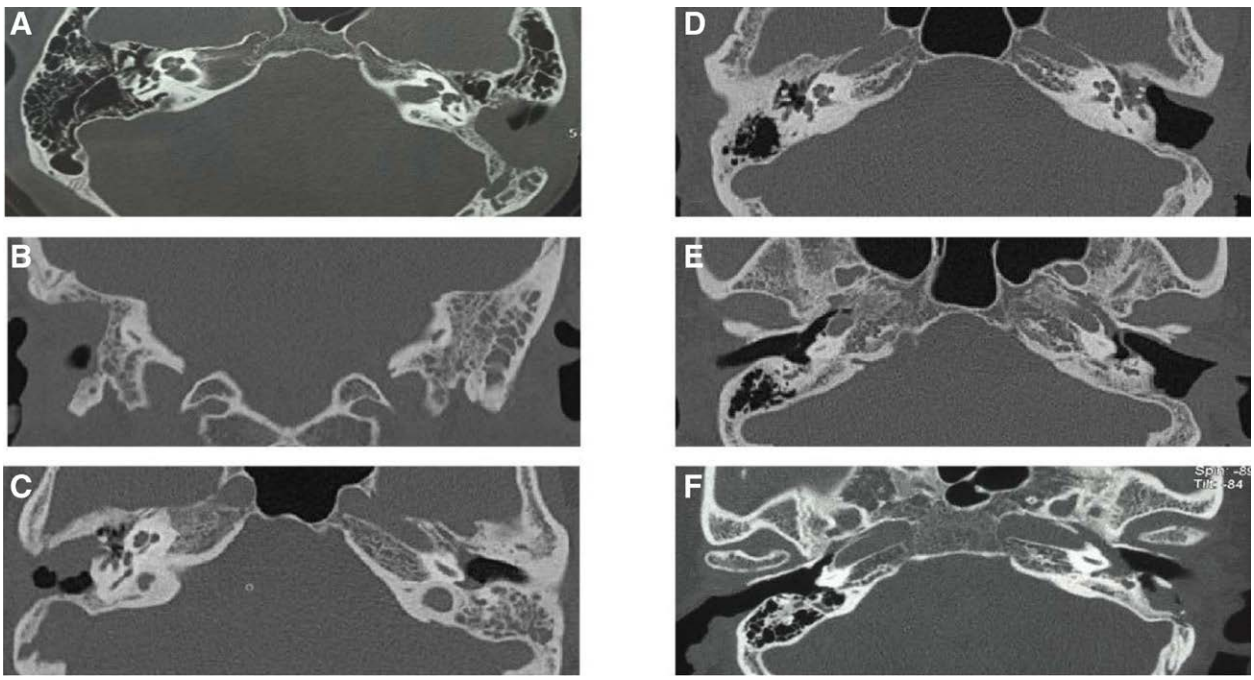

Figure 1. Representative cases in preoperative temporal bone CT cans. (A) Inadequate opening of the left mastoid tip air cells. (B) Inadequate opening of the sinodural angle. (C) Inadequate opening of air cells surrounding the right facial nerve. (D) Insufficient drainage of the surgical cavity with high left facial ridge. (E) The inflammation of the right eustachian tube. (F) Granulation tissue in the right eustachian tube. CT = computed tomography.

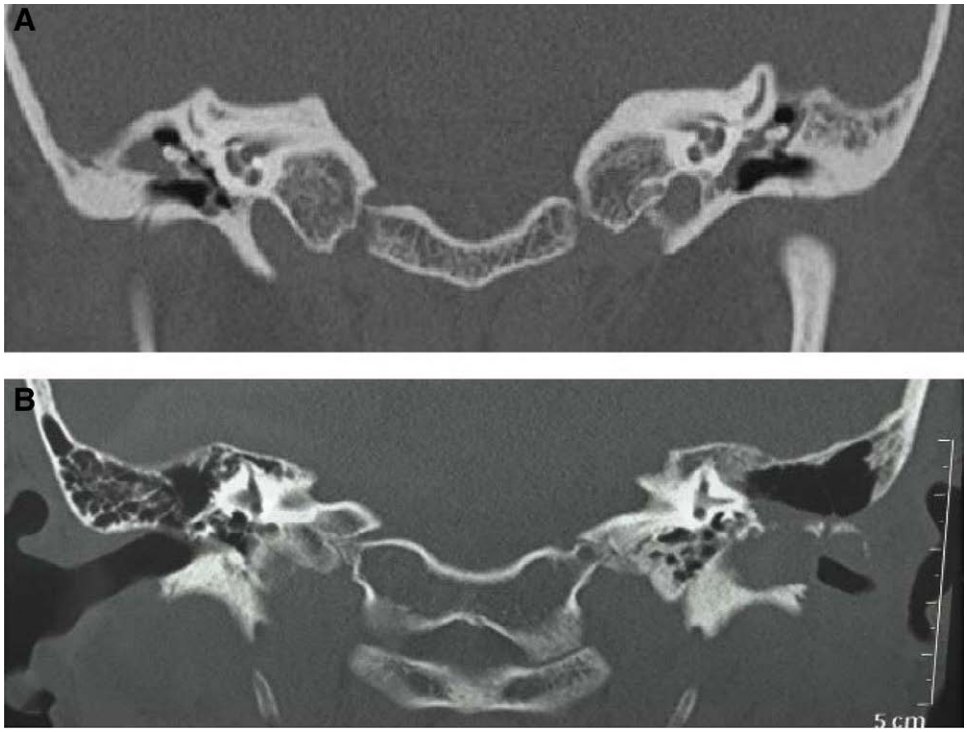

Figure 2. Representative cases of retraction pockets by selecting incorrect surgery techniques in primary mastoidectomy. (A) No reconstruction of the external auditory canal posterior wall after upper tympanic surgery. (B) Performation of soft-wall reconstruction surgery under the severe damage of the posterior wall of the external auditory canal.

epitympanic recess, consistent with the findings reported by Li et al.[9] Prasanna Kumar et al described cholesteatoma at the sinodural angle (63%), and inadequate reduction of the posterior canal wall flush with the external auditory canal were the main concerns for recurrent or residual disease.[10] For the 19 ears (41.3%) exhibiting insufficient opening of the posterior tympanum, we removed the outer wall of the tympanic cavity and ground the facial neural crest low, which was useful in fully opening the posterior tympanum and forming a spacious surgical cavity with the external auditory canal and mastoid cavity to thoroughly remove lesions during surgery. Damage to the facial nerve should be avoided during surgery.

Postoperative drainage of the surgical cavity is also necessary to achieve dry ears. In our study, stenosis of the external auditory canal was present in 29 ears (63.0%) and was caused by failure to perform conchaplasty after CWD mastoidectomy, insufficient resection of the cartilage during conchaplasty, and scar contracture. In scar diathesis patients, the dilation tube can be retained in the surgical cavity for 3 months to prevent stenosis of the external ear canal caused by scar contracture. A high facial nerve ridge also affects the drainage of the surgical cavity by obstructing the excretion of secretions and crust and has been implicated as a common cause of mastoid surgery failure. A high facial nerve ridge was present in 24/46 ears (52.2%) in our cases, which could have been caused by inadequate surgery because of the surgeon's unfamiliarity with the middle ear and facial nerve structures.

In chronic otitis media or middle ear cholesteatoma, lesions in the eustachian tube can impair pressure-regulating function, leading to residual secretions and aggravating the disease condition.

Table 3

Summary of surgical techniques in revision mastoidectomy.

Surgical techniques for revision mastoidectomy	No. of ears
MRM, tympanoplasty (type II), and plastic repair of the conchal cavity via conchaplasty	24
MRM, tympanoplasty (type II), and reconstruction of the posterior bony wall of the ear canal	5
MRM, tympanoplasty (type III), and conchaplasty	8
MRM, tympanoplasty (type III), and reconstruction of the posterior bony wall of the ear canal	3
MRM and conchaplasty	6

MRM = modified radical mastoidectomy.

Table 4

Pre and postoperative hearing variables of patients underwent tympanoplasty.

Type of tympanoplasty	Audiometric parameters	Preoperative	Postoperative	*P* value
Type II (n = 29)	AC* (dB)	54.3 ± 10.1	39.2 ± 9.3	.0278
	BC* (dB)	16.8 ± 5.1	17.1 ± 3.7	.6017
	ABG* (dB)	37.5 ± 3.6	22.1 ± 9.4	.0047
Type III (n = 11)	AC* (dB)	51.9 ± 10.7	42.2 ± 11.1	.0367
	BC* (dB)	17.3 ± 4.2	17.2 ± 5.1	.5236
	ABG* (dB)	34.6 ± 8.5	25.0 ± 4.4	.0032

ABG = air–bone gap, AC = air conduction, BC = bone conduction.
*Frequency of 0.5, 1, 2, and 4 kHz.

We considered it necessary to examine the eustachian tube during radical mastoidectomy. Ten ears had lesions in the eustachian tube orifice in preoperative temporal bone CT scanning, showing inflammatory edema of the mucosa or blockage by granulation or cholesteatoma tissue in the current study. The complete removal of lesions and the restoration of the eustachian tube function are key factors in successful surgery. Closing the eustachian tube has been suggested to prevent infections in the eustachian tube in patients who are not eligible for tympanoplasty and hearing reconstruction.

CWD is a common procedure for patients with lesions in the upper tympanic chamber. In CWD, reconstruction of the lateral wall of the upper tympanic cavity should be performed after excision of the lesion in the lateral wall to prevent the formation of an attic retraction pocket and cholesteatoma recurrence. Reconstruction of the posterior wall of the external auditory canal is particularly important during middle-ear cholesteatoma surgery.[11] Soft-walled canal wall reconstruction tympanoplasty is performed with an autologous soft tissue graft,[12] such as the temporalis fascia and a local muscle flap,[13,14] cartilage graft,[13] or an amniotic membrane.[15] For the 4 ears with retraction pockets in our cases, 3 ears underwent reconstruction of the posterior wall of the external auditory canal with autologous mastoid cortical bone, and reconstruction of the lateral wall of the upper tympanic cavity with autologous auricular cartilage was performed in the other 3 ears. Satisfying surgical results were achieved in revision radical mastoidectomies.

If the mastoid is of the gasification type, CWD mastoidectomy is usually not performed because of the inability to sufficiently expose all air cells. If an advanced sigmoid sinus and a lower dural plate of the middle cranial fossa are present, CWU is usually not performed because of the inability to remove all the diseased tissue intraoperatively. In our study group, 1 gasification radical ear presented with an advanced sigmoid sinus and lower dural plate, and CWD was performed during primary mastoidectomy. The cholesteatoma recurred due to insufficient resection of the lesions at the sinus meningeal angle. In revision mastoidectomy, we removed the posterior wall of the external auditory canal and reconstructed it using hydroxyapatite. Dry ears were achieved 2 months after surgery.

5. Conclusion

In this retrospective study, we analyzed the main causes of dry ear failure and cholesteatoma recurrence in radical mastoidectomy, which included inadequate exposure of the mastoid cavity, incomplete removal of pathological tissue, poor drainage of the surgical cavity, lesions in the tympanic ostium of the eustachian tube, and incorrect selection of the surgical technique. Based on the reasons for failure, the corresponding treatment was undertaken to achieve dry ears during revision surgery. However, the possible risk factors for otorrhoea were not considered in this study, such as concomitant diseases and mental disorders. Further long-term outcomes are required to observe these disorders of patients. We think improvement in the qualifications of the operators, advanced surgical equipment, and intensive postoperative care are useful to prevent these complications.

Author contributions

Conceptualization: Shusheng Gong, Chaoshan Wang.
Data curation: Ly Li, Jing Xie.
Formal analysis: Ly Li, Jing Xie.
Resources: Jing Xie.
Visualization: Chaoshan Wang.
Writing – original draft: Ly Li.
Writing – review & editing: Shusheng Gong, Jing Xie, Chaoshan Wang.

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