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Review Article

Aeromedical disposition dilemma: Renal calculi

P Renjhen

Specialist (Senior Advisor) in Aerospace Medicine and SMO, Air Force Station, Chandigarh, India.

***Corresponding author:**
Dr. P Renjhen, MBBS, MD,
Specialist (Senior Advisor)
in Aerospace Medicine (IAF)
and SMO, Air Force Station,
Chandigarh, India.

piushrenjhen@gmail.com

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ABSTRACT

Renal colic is a condition which causes acute pain of variable intensity. At times, this makes the sufferer visibly powerless and prevents him from performing any skilled task satisfactorily. The most common cause of the symptom is related to a calculus, which is moving inside the ureter inducing ureteral spasm. A military aircrew is declared unfit to fly in case he/she is detected to have renal calculi. At present, with the newer and advanced investigation techniques, the detection of even small renal calculi is possible. This has led to an increase in clinical data. Since the clinical outcome of renal calculi is unpredictable, aeromedical disposition becomes a challenging task for such cases. The paper brings a review of existing disposition guidelines for cases of renal calculi both in the military and civil aviation in different parts of the globe. An attempt is also made to present an approach toward aeromedical certification and surveillance in the form of a proposed decision algorithm to be used by the flight surgeon.

Keywords: Renal calculi, Parenchymal calcification, Randall's plaques, Aeromedical certification

INTRODUCTION

Renal colic is the most common presenting symptom of renal calculi. This pain is related to the position and movement of the calculus inside the ureter, causing acute ureteral spasm.[1] At times, this makes the sufferer visibly powerless and prevents him from performing any skilled task satisfactorily. Thus, the severity of renal colic presents a very tangible risk of inflight incapacitation during an acute episode. However, quantifiable data related to such incapacitation is not available as far as military or civil flying in India is concerned. Considering the flight safety, there is a need for a comprehensive assessment toward the aeromedical disposition in such cases. As per the existing guidelines, the military aircrew with renal calculi (irrespective of location/size) is not assessed fit for flying duties until successfully operated or free from stone.

The investigational techniques have become more sensitive with the advancements in technology and this has led to a large increase in clinical data. In his editorial for Journal of Urology, Robert Nadler stated "technology, especially computed tomography (CT) technology is revolutionizing the way urologists think about stone."[2] The availability of more accurate imaging has also impacted the diagnosis, management, and surveillance of renal calculi in the aviation community.

The concerned medical authority has been receiving many more incidental reports of renal calculi and renal concretions in the pelvicalyceal system and the renal parenchyma, largely from CT scans performed either for urological or nonurological indications, which raise questions about appropriate aeromedical management. Another consequence is that smaller stones are now being detected. The symptomatic significance of these stones is controversial and warrants a considered aeromedical disposition.

The paper discusses the different dispositions for cases of renal calculi in the military aviation and civil aviation in different parts of the globe. Finally, an approach to aeromedical certification and surveillance is presented in the form of a proposed decision algorithm to be used while disposing military aircrew.

This review was prompted by the observation that many pilots appeared to be undergoing multiple high-dose CT scans during the management of renal calculi. In addition, there has been a steady increase in the number of "incidental" calculi diagnosed and clinical management of calculi has been highly variable. There were cases where the calculi were located in the parenchyma and the aircrew was asymptomatic but had to be placed in low medical category as per the existing medical policy/guidelines. Medical information database available at higher medical authority was retrieved and analyzed. The medical files were reviewed along with literature in this regard. A total of eight (n = 8) aircrew were found to be in low medical category with renal calculi detected on CT scan.

As per the existing medical guidelines, all aircrew were in low medical category (LMC) irrespective of the location or site of the stone. Those with parenchymal lesion or with renal concretions were also placed in LMC as the presence of renal calculi entails nonflying category until successfully operated.

DISCUSSION

Aviation specific occurrence data for renal colic are limited to isolated case reports and therefore quantifying the risk of acute colic in aircrew is conjectural at best.[3] A very low reporting frequency in aircrew suggests that many episodes are not recorded as compared with studies of the general population. In the USA, the annual incidence of renal colic is 116–208/100,000 and in Germany, up to 720/100,000.[4] Population prevalence has been reported between 1% and 10% in Asia, between [illegible]% and 15% in the United States and Europe, and 20% in Saudi Arabia.[5]

Low-dose CT in 5047 asymptomatic adults found 7.8% (9.7% men and 6.3% women) with calculi. An analysis of incidental findings on virtual CT colonoscopy found 13.9% patients with renal calculi. There were 59% who had stones under 3 mm in size, 20% between 3 mm and 5 mm, 18% between 5 mm and 10 mm, and 3% over 10 mm.[6]

Given the frequency of this incidental finding, particularly on CT scans, the question for regulators/policymakers is whether this high prevalence translates into symptomatic disease. What is the risk associated with this previously undetected and asymptomatic finding? Glowacki *et al.* reported a cumulative 5 years symptomatic event probability of 48.5% and a peak incidence 3 years after incidental detection of a calculus.[7] More recently, a larger study demonstrated 20.5% of a population with calculi had at least one symptomatic episode over a 10 year period.[8] This equates to an annual incidence of symptomatic disease between 2% and 10%, a rate which is well within the realm of aeromedical significance.

A prospective study followed 160 patients with 4 mm or smaller asymptomatic calcium oxalate or calcium phosphate stone fragments after lithotripsy for a mean of 23 months. Of these patients, 43.1% had a symptomatic episode or required intervention [illegible]–85.4 months (mean 26 months) after their treatment, a probability estimate of 0.71 at 5 years.[9] Khaitan *et al.* reviewed [illegible] patients with 4 mm or smaller residual fragments and noted that 44 (59%) eventually required intervention.[10,11] Raman subsequently reported 43% of patients with a residual calculus (median size 2 mm) having a stone-related event a median of 32 months after percutaneous nephrolithotomy.[12] Analysis of patients with residual fragments post-ureteroscopic treatment for a mean 18.9 months reported a stone event in 19.6%.[13] Small calculi, and particularly residual fragments smaller than 5 mm, have been termed "insignificant." The incidence of symptoms and surgical intervention described above suggests that, at least for aircrew, this is an inappropriate descriptor and may give a false sense of security.

Stone growth has been shown to be greater in lower pole stones compared with upper or middle pole stones, but less than pelvicalyceal stones. However, there was a similar incidence of pain in all sites, ranging from 40% to 50% of cases.[14] The location of residual fragments does appear to be relevant to recurrence rates following treatment. It is also reported that the stone size does not correlate well with severity of symptoms.

The following requirements are needed for urinary stone formation: (a) formation of a crystal nidus through nucleation, (b) retention of the nidus within the urinary tract, and (c) growth of the nidus to a size sufficient to cause symptoms or be visible on imaging.

Parenchymal calcification and Randall's plaques

Many CT shows papillary calcification and, in the past, it has been considered to be of little significance in urological reports. From the perspective of risk assessment and determining surveillance, however, it is a significant finding. Electron microscopy has demonstrated unattached calcium oxalate stones embedded in calcified renal tubules.[15] Furthermore, idiopathic calcium oxalate stone formers have been shown to develop calculi on renal papillae attached to an underlying apatite deposit or Randall's plaque.[16] This understanding of the pathogenesis provides an indication at an early stage of the possible development of calculi, permitting surveillance as well as being an incentive to the pilot or controller to address any treatable underlying cause. Thus, identification of papillary calcification or Randall's plaque places an individual at an elevated risk of developing a calculus and subsequent colic.

Diagnostic techniques have taken advantage of the calcium content in approximately 90% of calculi. Plain abdominal films have an overall sensitivity of approximately 50%. Ultrasound is a noninvasive method for demonstrating both the urinary stone and the resultant hydronephrosis and has a high specificity, but low sensitivity. CT scans are regarded as the gold standard for diagnosis, with a high sensitivity for calcium-containing calculi.[17] In addition, they provide a better localization of calculi, which is helpful in determining if the calculus is intraparenchymal or in the collecting system.

Aeromedical assessment

The decision to waiver disqualifying medical conditions is a balance between the potential risks of a medical emergency with the loss of service of a highly trained pilot. In the case of nephrolithiasis, it is the risk of in-flight incapacitation secondary to excruciating pain. The presence of a calculus in the renal collecting system is considered of aeromedical significance due to the high risk of symptoms. Acute colic is usually incapacitating.[5] While there are a number of effective treatment and lifestyle interventions to reduce the likelihood of an episode, there are only limited operational mitigations available to manage the consequence. Unrestricted certification, therefore, presents an unacceptable risk. Pilots with calculi may be eligible to operate if a safety pilot is available, or possibly in a multi-crew environment.

Textbook on Clinical Aviation Medicine by Rayman[18] mentions that renal parenchymal calcification may be due to a number of underlying diseases or may be idiopathic. In the former cases, flight status must be determined primarily by the underlying condition. For idiopathic cases, major determinant of aeromedical disposition is the position of calcific deposit. Medical waivers may be granted without threat to flight safety if there is a reasonable certainty, as demonstrated by imaging, that the calcification is totally within the renal parenchyma or within cysts (such as in medullary sponge kidney), with no possibility of migration into the collecting system. In this situation, there is little risk for the stone to move and cause incapacitating pain.

Policies in different military and civil aviation

At present, each branch of the U.S. Armed Forces has its own set of guidelines dictating how aviation personnel with nephrolithiasis is managed.

1. US Navy: Medical standards for Navy pilots and aircrew are dictated by the Naval Aerospace Medical Institute (NAMI) in the Aeromedical Reference and Waiver Guide (ARWG).[19] The current NAMI policy is very clear in stating that any aircrew member with a retained stone in the collecting system is ineligible for a waiver until confirmed to be free of stones.
2. US Air Force: Medical standards for the U.S. Air Force Aircrew are contained in the U.S. Air Force Waiver Guide.[20] In the US Air Force, renal stones, or a history of renal stones, are disqualifying for all flying classes. No waiver is required for a single episode in a trained aviator unless retained stones are present. However, a full metabolic workup is required after a single episode of nephrolithiasis. Following a recurrent episode, pilots need to be stone-free for waiver consideration unless they fly with another trained pilot; a restricted waiver is considered for them if they are asymptomatic, particularly if they have 3 or less stones that are <4 mm in size. These aviators are typically followed every 6-12 months for a change in the size of the calculus, and if stable over a year, annual follow-up is deemed safe. The same protocol is followed for asymptomatic stones found incidentally on imaging studies. In all instances, metabolic risk factors for stone disease are appropriately addressed before waiver is considered.
3. US Army: Medical standards for the U.S. Army aircrew are contained in Army Regulation 40-51, as well as the Army's Aeromedical Policy Letters.[21] Army concerns parallel those of the Air Force, though there are few operational missions flown single pilot in the Army which decreases the aeromedical risk. The workup includes 24 h urine chemistry, standard urinalysis, analysis if possible, and imaging after stone passage. A urology consultation is critical to assess propensity for stone formation in the future. With regard to applicants for flight training, waivers are not generally granted. For rated aircrew members with a history of a solitary unilateral kidney stone that has resolved and a normal metabolic workup, no waiver is generally required. Waivers are granted for the presence of retained stones, provided they are in the renal parenchyma, the metabolic workup and renal function are normal, and the patient is asymptomatic. Retained stones within the calyx must be too large to pass into the ureter. If the metabolic workup is abnormal, a waiver may be requested if the metabolic condition can be controlled with approved medication.
4. US Coast Guard: Medical standards for the U.S. Coast Guard aircrew are contained in the Coast Guard's Aeromedical Policy Letters.[22] The U.S. Coast Guard waiver guide does not make explicit mention of waiver possibilities for retained stones in the collecting system. History of urinary tract stone formation or retention

of urinary tract stone within the collecting system is disqualifying for aircrew. Difficulty in controlling a metabolic abnormality may result in a permanent disqualification.

5. FAA: The U.S. Federal Aviation Administration sets forth aeromedical guidance and policy for civilian aviators in its Guide for Aviation Medical Examiners.[23] The Federal Aviation Administration currently allows pilots to fly with retained stones as long as they are not in the collecting system, akin to most military policies.
6. JAA. The Joint Aviation Authorities (a European consortium governing civil aviation in member countries) state that a pilot with retained calculi can be found fit for flying duties if restricted to multi-piloted aircraft or when a safety pilot is aboard.[24]
7. Australian CASA: The Australian Civil Aviation Safety Authority places similar restrictions on their pilots.[25] Where stone material remains in the renal substance or urinary tract, CASA will not permit unrestricted certification unless there are clear mitigating factors that preclude renal colic, such as a staghorn calculus, a calculus in a diverticulum, or a stone clearly embedded in the renal substance. (Further stone movement is extremely unlikely in such cases). Pilots or ATCs with staghorn calculi may be suitable for certification, on a case-by-case basis, until stone removal, provided they are asymptomatic, their renal function is normal, and movement of the calculus is considered unlikely.
8. RAF: The Royal Air Force mentions that aircrew are to be grounded until stone free. Aircrew with recurrent RSD or with residual stones not amenable to treatment are referred to the CA in Renal Medicine. If residual stones are considered unlikely to become symptomatic, a return to restricted flying (A3, "Unfit solo pilot – must fly with a pilot suitably qualified on type") or equivalent for other aircrew roles should be possible.[26]

All of these standards are quite similar in nature and unanimously state that after an instance of nephrolithiasis, the aircrew members is grounded until completion of an extensive metabolic workup, radiologic imaging, and, often, urological consultation. The need for proper medical management of aircrew members with kidney stones is well established and not in debate.

While this process is nearly identical across the services, there are some differences with regard to aeromedical waivers and returning to flight operations following a diagnosis of nephrolithiasis. Certain agencies permit aircrew to fly with retained stones in renal parenchyma after a thorough assessment wherein a chance of renal calculus moving in the collecting system is negligible. The existing waiver potential regarding retained renal calculi among international aviation authorities and IAF is presented in Table 1, authorities and IAF is presented in Table 1.

Table 1: Waiver potential regarding retained renal calculi among international aviation authorities and IAF.

Aviation authority	Calculus location	
	Renal parenchyma	Collecting system
U.S. Navy	Yes	No
U.S. Air Force	Yes	Yes, aviation class-dependent
U.S. Army	Yes	Not specified
U.S. Coast Guard	Yes	Not specified
Federal Aviation Administration	Yes	No
Joint Aviation Authorities	Yes	Yes, with restrictions
Civil Aviation Safety Authority	Yes	Yes, with restrictions
Royal Air Force	Not specified	Yes, with restrictions
IAF	No	No

IAF: Indian Air Force

CONCLUSION

An in-flight exacerbation of renal colic constitutes a significant threat to aerospace safety. Limited aviation occurrence data currently force reliance on general population studies, where this is a common and incapacitating problem. These considerations highlight the need for robust multifactorial aeromedical assessment of renal calculi.

Changes to well established aeromedical policies that protect against such mishaps should not be made hastily or without careful consideration of all the pertinent information.

The universal aeromedical policy of grounding aircrew members with nephrolithiasis, pending work-up, has proven to be effective in preventing mishaps and should continue. The pain from renal colic can be so debilitating as to compromise not only flight safety but also overall mission completion.

Aviation authorities should examine waiver requests on a case-by-case basis, accounting for aviation platform and aircrew position, instead of having blanket policies prohibiting waivers based on the location of renal stones. The authorities should also continually re-examine their policies and review the current literature to provide the best guidance on the optimal medical and surgical management of both pilots and other aircrew members with kidney stones.

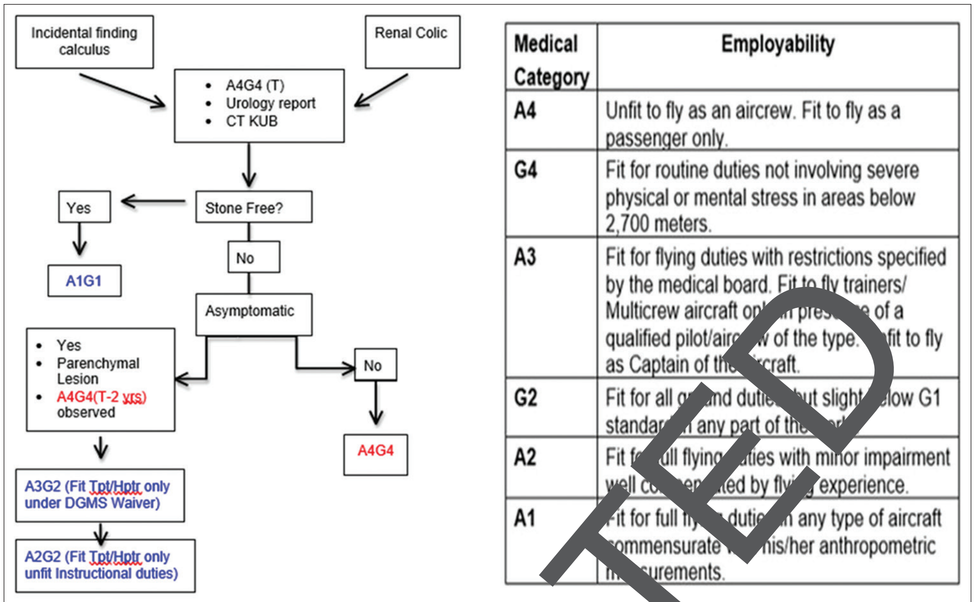

Figure 1: Proposed algorithm for medical disposition of the aircrew with renal calculi and colic

RECOMMENDATIONS

The proposed algorithm for medical disposition of the aircrew with renal calculi and colic is given in Figure 1.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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