Comprehensive management of paranasal sinus fungus balls: a Young-IFOS consensus statement

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ABSTRACT

Background: Paranasal sinus fungus balls (PSFB) are a common form of surgically treatable, non-invasive mycosis. To date, no guidelines have standardized PSFB treatment or the management of difficult cases (e.g., immunocompromised or fragile patients). The clinical consensus statement presented here aims to provide a comprehensive management guide to PSFB based on current evidence.

Methods: A multidisciplinary, international panel of 19 specialists judged statements in three rounds of a modified Delphi-method survey. Statements encompassed the following PSFB management issues: definition, diagnostic workup, treatment indications and modalities, and follow-up. Otolaryngologists, maxillo-facial surgeons, infectious disease specialists, and transplant physicians were considered the target audience.

Results: Among the 23 statements, 7 reached strong consensus, and 16 reached consensus. Consensus was reached on the definition, diagnosis, and treatment modalities for PSFB. Postoperative follow-up modalities and scenarios with bacterial superinfection were the most debated issues.

Conclusions: Until further data are available, these points provide a framework for the management of PSFB. Moreover, PSFB should be considered a non-invasive mycosis that is not necessarily symptomatic or related to odontogenic conditions. Although diagnosis may be incidental, endoscopy and single-imaging (CT or MRI, with distinctive features) are required for diagnosis, while contrast medium would allow for differential diagnosis. Although treatment of PSFB should be considered mandatory prior to sinus

augmentation and is recommended for symptomatic patients, immunosuppressed patients, or patients with planned immunosuppression, watchful waiting could be considered for asymptomatic patients with chronic rhinosinusitis (CRS) who are provided with appropriate advice and assessment.

INTRODUCTION

Paranasal sinus fungus balls (PSFB) are generally considered a form of non-invasive mycosis[1] mostly affecting the maxillary sinus, with less common extra-maxillary or multiple presentations.[2] PSFB incidence appears to have increased in the last 15 years, with up to 8.3% of affected patients undergoing endoscopic sinus surgery (ESS).[3]

Most likely due to the generally favorable prognosis and consistently high rate of resolution after ESS, which should be regarded as the sole first-line treatment option, PSFB has not been addressed by specific management guidelines to date and is only marginally considered as a causative factor in secondary rhinosinusitis.[4]

The aim of this clinical consensus statement (CCS) is to offer, through a modified Delphi process, specific management guidelines for PSFB, based on the best evidence currently available, covering all disease management issues, and offering a reference for the most common difficult clinical scenarios.

METHODS

The development of this CCS followed the modified Delphi protocol proposed by Rosenfeld et al.[5] Due to the nature of the study, no specific approval by an Internal Review Board was required.

Panelists and Scope of Consensus Statement

The panel was composed of 19 collaborators from 6 European and North American countries. The development group consisted of a chair (AMS), assistant chair (LS), and

methodologist (FA). Rhinologists were recruited from the rhinologist section of the Young Otolaryngologist – International Federation of Otorhinolaryngological Societies (YO-IFOS) research group, while non-otolaryngological authors were selected according to their specialty training, in the context of other ongoing research collaborations with the group. The YO-IFOS research group is an invitation-only group, whose members are selected by the elected scientific committee of the YO-IFOS among worldwide board-certified otolaryngologists younger than 45 years of age and on the basis of the extent and impact of their scientific achievements The group is further subdivided according to members' subspecialties. As is the case for this CCS, members are free to propose new projects and participate in proposals according to their areas of expertise (though one completed proposal and two participations every 24 months are required to retain membership). The panel for this CCS was ultimately composed of 14 rhinologists, one epidemiologist, one infectious disease specialist, one transplant specialist, and two maxillo-facial surgeons. No conflicts of interest emerged among the authors. The focus of the CCS was to offer specific guidance for the management of PSFB.

Literature Review

A PRISMA-compliant systematic review of the literature was conducted for PSFB management in the MEDLINE, EMBASE, Scopus, and Web of Science databases.[6] Broad search strategies for "fungus ball" and all related terms in association with paranasal sinuses, nose, and related terms, were used on December 2nd, 2021 to look for studies in English, Italian, German, French, or Spanish that reported data obtained from human subjects. Supporting Information 1 reports the search strategies for all queried databases. Due to a lack of high-quality studies on the topic, the systematic review was

extended from what had been originally been recommended for CCSs[5] (i.e., guidelines and systematic reviews) to include all original studies published on the topic, with the exclusion of case reports and non-original articles (such as narrative reviews).

Upon retrieval of the literature identified by the systematic review, a collection of 84 articles, representing the best evidence on the topic (i.e., higher-evidence-level studies and case series with at least 20 patients), was prepared and distributed to all authors to be reviewed over a period of 1 month. Figure 1 shows a PRISMA flow chart of the article selection process.

Clinical Statement Development and Modified Delphi Survey

Based on the literature review and the aim of the CCS, the chair and assistant chair developed the core clinical statements for the survey, which were further discussed, expanded, and edited by the methodologist.

Statements were developed based on the literature review and the development group's perception of important clinical scenarios. A final 23-statement survey was therefore created and distributed to the authors using Google Forms (Google LLC, Mountain View, CA, USA). Authors were instructed to complete the survey anonymously via a personalized and single-use link. Authors were asked to report their agreement with each statement according to a 9-point Likert scale from strongly disagree (1) to strongly agree (9). As defined by Rosenfeld [13] the results for each statement were defined as follows: strong consensus: mean score of ≥ 8.00 with no outliers (defined as any rating 2 or more Likert points from the mean in either direction); consensus: mean score of ≥

7.00 with no more than 1 outlier; near-consensus: mean score of ≥ 6.50 with no more than 2 outliers; no consensus: all other statements.

After the first survey round, three of 23 statements reached a strong consensus, seven of 23 statements reached a consensus, four reached a near-consensus, and nine reached no consensus. The 13 near- or no consensus items were rephrased based on anonymous comments from the authors for inclusivity and clarity. The second survey round included 13 statements, of which four reached a strong consensus, six reached a consensus, one reached a near-consensus, and two did not reach a consensus. After a second rewording, a third 3-item round was prepared, in which all three items reached a consensus.

RESULTS

All panelists took part in the three Delphi rounds, although two rhinologists missed one Delphi round each. After the three Delphi rounds, seven out of 23 statements reached a strong consensus, and the remaining 16 reached a consensus. The evolution of statements from the first round to their final version is reported in Supporting Information 2. Delphi process results for all statements, along with their mean score, median score, score range, and the respective number of outliers are reported in Table 1.

The two highest-scoring strong consensus items were “PSFBs may be diagnosed incidentally during other diagnostic workups without any accompanying symptoms” (mean score 8.64, median score 9) and “PSFB treatment is highly recommended in immunocompromised patients, especially in cases of secondary chronic rhinosinusitis

(CRS)" (mean score 8.58, median score 9). Six out of 23 items recorded a median score of 9.

The lowest-scoring items (mean and median scores of 7.61 and 7.5, respectively for both items) were "Endoscopic findings of purulence, edema, or polyps and involvement of > 1 paranasal sinus may suggest the presence of secondary sinusitis with bacterial superinfection, obstructive rhinosinusitis or evolution towards invasive forms" and "Surgical treatment should be considered for asymptomatic PSFBs with suspected or ascertained secondary CRS, although clinical and radiological follow-up represent an alternative in immunocompetent patients".

DISCUSSION

The multidisciplinary group of experts involved in the creation of the Delphi-method consensus statement presented here has delineated a specific all-around management guideline for PSFBs, thereby covering an important gap in the literature.

High success rates in the treatment of PSFBs have been reported (i.e., 98.4% after surgery in a recent meta-analysis,[2] and 98.8% in the largest available case series[7]). The present CCS is unlikely to improve these figures. Rather, it aimed to contribute to streamlining the diagnosis and therapeutic process, with a particular focus on unusual/uncommon clinical situations not covered by the available literature. This means improving the overall standard of care for patients and offering guidance to general otolaryngologists when managing difficult cases or to allied specialties in referring patients for rhinological evaluation. The overall need for standardizing PSFB

care emerges from the almost-constant presence of outlier results among our specialist-evaluated 23 consensus statements, even in sections on the definition of disease.

It should be noted that most reports in the literature suggest that PSFB treatment is solely surgical, and that medical treatments (especially antifungals) should not be considered a first-line option and their use should be employed only in specific cases, which are detailed in the CCS.

In terms of disease definition, the CCS confirmed the use of the DeShazo et al. classification,[8] as well as the non-routine inclusion of PSFB among odontogenic sinusitis cases as suggested by Craig et al.[9] Odontogenic sinusitis cases, whether or not presenting with maxillary PSFB, might be better defined according to different existing consensus docuements.[9]

From our CCS, it emerged that the existence of both symptomatic PSFB (i.e., presenting with cacosmia, facial pain, nasal obstruction, or recurrent bleeding) and asymptomatic/incidentally found PSFB is widely accepted. Symptoms are important in the evaluation and management of patients, but they are not required for nosographic purposes, unlike a CRS diagnosis.[4] It was also accepted that nasal endoscopy should be considered as a minimum standard in the diagnosis of PSFB, together with at least one CT scan or MRI. It was also accepted that nasal endoscopy should be regarded as a minimum standard in PSFB diagnosis, coupled with at least one between computed tomography or magnetic resonance imaging. Typical computed tomography findings (an iron-like core - i.e., foci of calcific deposits mimicking a metallic foreign body inside the sinus - or surrounding bone hyperostosis) and magnetic resonance characteristics (T2 signal void) strengthen a PSFB diagnosis and do not require contrast medium administration. The latter should be reserved for evaluating differential diagnoses or

invasive behaviors that have been occasionally described.[10] A more disputed issue, though reaching consensus, was delineating the role of PSFB accompanied by endoscopic findings of purulence, edema, or polyps and involvement of more than one paranasal, which were deemed signs of secondary sinusitis with bacterial superinfection, obstructive rhinosinusitis or evolution toward invasive forms, as the literature indicates that PSFB should not be characterized by purulence or bacterial superinfection per se.[11] Literature reports seem to suggest that bacterial superinfection might characterize more symptomatic cases, as well as characterize all cases of PSFB with underlying odontogenic sinusitis.[12,13]

Indications for treatment in standard and specific cases are the most important result of this CCS, as the present literature does not cover extensively these scenarios, which are nevertheless commonplace in clinical practice. The basic assumption is that PSFB does not necessarily require treatment, per se, and its management should be integrated with specific patient characteristics. The CCS concluded that the benefit/risk balance in PSFB favors treatment in some specific cases, while other patients might choose watchful waiting, given appropriate counseling. Therefore, PSFB treatment is favored in the following cases: prior to maxillary sinus augmentation procedures (i.e., procedures aimed to increase the posterior maxilla vertical bone height placing a bone graft under the sinus mucosa allowing for dental implant placement - mandatory PSFB treatment), prior to planned iatrogenic immunosuppression or in immunocompromised patients (highly recommended, more even so if secondary rhinosinusitis develops), in symptomatic immunocompetent patients (recommended), and prior to upper jaw implant positioning (recommended). On the other hand, watchful waiting with adequate clinical and radiological follow-up was considered an appropriate option to be offered

to selected patients in cases of asymptomatic PSFB with normal immunocompetence and no secondary rhinosinusitis, especially in patients with high comorbidity and relevant anesthetic risk. Finally, immunocompetent patients showing PSFB with signs of secondary rhinosinusitis represent something of a middle ground, where surgery represents the best option, but careful follow-up should be considered, nonetheless.

Not surprisingly, endoscopic sinus surgery aimed at all involved sinuses was considered the only treatment option for PSFB in this CCS, with lavages and appropriate access used to completely remove the hyphal material. The CCS suggests limiting the use of antifungal therapy to cases with confirmed mucosal or soft tissue invasion (i.e., when PSFB is not present by definition) and employing antimicrobial therapy (possibly culture-driven) in cases with suspected bacterial superinfection of concomitant secondary rhinosinusitis. Mucosal biopsies, which some authors advocate in all PSFB cases,[14,15] were deemed helpful in ruling out suspected invasive forms or other differential diagnoses, or for research purposes, while hyphal material evidence was considered enough in highly suggestive PSFB scenarios, thus streamlining the diagnostic process.

The postoperative follow-up was the most debated single feature of PSFB management, due to the extremely scarce amount of evidence. Ultimately, the CCS found it reasonable that findings of a normal postoperative endoscopy with widely patent ostia were sufficient to end patient follow-up and suggested a 6-to-24-month follow-up in high-risk patients (defined as immunocompromised, multimorbid, or incomplete hyphae excision) for early recurrence detection. Furthermore, the panelists suggested that follow-up should rely primarily on nasal endoscopy, limiting the use of postoperative

imaging only to suspect recurrences, or in patients where unfavorable anatomy or post-surgical features hinder the full exploration of previously affected sinuses.

While these general management indications are not meant to revolutionize PSFB treatment, it is our firm conviction that they might assist in streamlining the patient care process, balancing the risks and benefits of treatment versus watchful waiting, and optimizing resource allocation.

The results of this CCS are limited by the low overall quality of the currently available scientific evidence on this topic, which is mostly based on retrospectively collected data. The currently available literature, as circulated among CCS participants from the systematic review, is detailed in Supporting Information 3, which also reports the clinical study type, the evidence level according to the Oxford Centre for Evidence-based Medicine (OCEBM) level of evidence guide,[17] and the size of the patient pool for each article.

There is an inherent need for prospective studies covering the more widely debated areas of PSFB emerging from this consensus, such as postoperative follow-up duration and the treatment of bacterial superinfections. The first issue is related to the cost-effectiveness of the protocols, such as avoiding unnecessary consultations with specialists, while the second issue could reduce recurrences to zero and avoid over-prescription of oral antibiotics, as has already been extensively demonstrated with ESS in other conditions.[16] Among other areas of research and standardization, it is worth mentioning that our CCS does not provide guidance on the interval between PSFB treatment and initiation of immunosuppression, maxillary sinus augmentation procedures, or dental implant positioning. It might be safe to assume that complete postoperative healing with no residual crusting, or evidence of hyphal material or

purulence could greenlight immunosuppression or dental procedures; however, additional focused research is needed in this regard. Furthermore, there is no consensus or literature guidance on the duration of follow-up in patients declining treatment or on the need for additional imaging in these patients. In this regard, patients' safety does not allow for suggestions to end follow-up, as local infection conditions may vary, even many years later, while imaging should be performed only when patients report worsening symptoms or the onset of new symptoms.

CONCLUSION

Until further prospective studies on PSFB are available, this consensus statement suggests that PSFB is best managed following these main tenets. PSFB should be considered a non-invasive mycosis not necessarily related to odontogenic conditions or symptomatic. Though diagnosis may be incidental, endoscopy and one imaging examination (either CT or MRI, with distinctive features) are required for diagnosis, while contrast medium allows for differential diagnosis. Though PSFB treatment should be considered mandatory prior to maxillary sinus augmentation and is recommended for symptomatic patients, immunocompromised patients, or patients with planned immunosuppression, watchful waiting could be considered when dealing with asymptomatic, non-CRS patients who are provided with proper counseling and evaluation.

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TABLES

Table 1 - Statements and results from the Delphi process.

Section	Item	Statement	Mean	Median	Range	Outliers	Final result
Definition	1a	PSFBs are per definition a non-invasive mycosis	7.84	9	1-9	1	Consensus (1st Delphi round)
	1b	Although correlations with dental treatments and conditions have been described, maxillary PSFBs should not be routinely considered as odontogenic sinusitis cases, even if underlying dental pathology is identified	7.94	8	5-9	1	Consensus (2nd Delphi round)
Diagnosis	2a	PSFBs may become symptomatic and cause cacosmia, facial pain, nasal obstruction, or recurrent bleeding	7.84	8	5-9	1	Consensus (1st Delphi round)
	2b	PSFBs may be diagnosed incidentally during other diagnostic workups without any accompanying symptoms	8.63	9	7-9	0	Strong consensus (1st Delphi round)
	2c	Nasal endoscopy and at least one imaging exam (either CT or MRI) is mandatory in suspect PSFB workup	8.37	9	7-9	0	Strong consensus (1st Delphi round)
	2d	PSFBs may present with distinctive radiological features such as hyperostotic changes in sinus walls, iron-like central cores, and sparse hyperdense sinus material at CT scans or T2 signal void at MRI scans	7.79	8	5-9	1	Consensus (1st Delphi round)
	2e	PSFB radiological workup can be completed with contrast medium CT or MRI scans if differential diagnosis with other unilateral paranasal sinus conditions or malignancies is required	8	8	5-9	1	Consensus (2nd Delphi round)

		or for ruling out suspect bony erosion, soft tissue invasion and/or cavernous sinus thrombosis					
	2f	Endoscopic findings of purulence, edema, or polyps and involvement of >1 paranasal sinus may suggest the presence of secondary sinusitis with bacterial superinfection, obstructive rhinosinusitis or evolution towards invasive forms	7.61	7.5	5-9	1	Consensus (2nd Delphi round)
Treatment indications	3a	Treatment is recommended for symptomatic immunocompetent PSFBs and for asymptomatic PSFB patients in cases of immunodepression or planned immunosuppression	8.28	8.5	7-9	0	Strong consensus (2nd Delphi round)
	3b	Surgical treatment should be considered for asymptomatic PSFBs with suspected or ascertained secondary CRS, although clinical and radiological follow-up represent an alternative in immunocompetent patients	7.61	7.5	6-9	1	Consensus (3rd Delphi round)
	3c	Maxillary PSFB treatment is mandatory prior to maxillary sinus augmentation procedures	8.37	9	6-9	1	Consensus (1st Delphi round)
	3d	Maxillary PSFB treatment is recommended prior to dental implant placement in the upper jaw	7.95	9	4-9	1	Consensus (1st Delphi round)
	3e	PSFB treatment is highly recommended in immunocompromised patients, especially in cases of secondary CRS	8.58	9	7-9	0	Strong consensus (1st Delphi round)
	3f	PSFB treatment is highly recommended prior to iatrogenic immunosuppression (e.g., transplant surgery), although such treatment can be delayed after starting urgent immunosuppressive treatments	7.78	8	5-9	1	Consensus (2nd Delphi round)
	3g	Watchful waiting could be considered when dealing with asymptomatic non-CRS PSFBs patients, especially in high anesthesiological risk co-morbid and	8	8	7-9	0	Strong consensus (2nd Delphi round)

		fragile patients, given proper counseling					
	3h	Patients with asymptomatic PSFBs should be adequately counseled in balancing the risks of surgical treatment with those of watchful waiting, according to the single clinical scenario and to the location of the mycosis	7.95	8	4-9	1	Consensus (1st Delphi round)
Surgical and medical treatment and follow-up	4a	PSFB treatment requires endoscopic sinus surgery, aimed at all involved sinuses identified via nasal endoscopy and/or imaging	8.53	9	5-9	1	Consensus (1st Delphi round)
	4b	Complete removal of fungal hyphae improves the chances of treatment success and should be achieved through adequately sized accesses to the affected sinuses and may be facilitated by intraoperative sinus lavages	8.44	9	7-9	0	Strong consensus (2nd Delphi round)
	4c	In cases of clinical scenarios highly suggestive for PSFB hyphal material, biopsy alone confirms the diagnosis, while mucosal biopsies are required only to rule out invasive forms or for differential diagnosis or research purposes	7.89	8	7-9	1	Consensus (3rd Delphi round)
	4d	Antifungal therapy should not be prescribed in PSFB treatment, either pre- or post-operatively, except in cases of confirmed mucosal invasion or bony erosion with soft tissue invasion	8.28	8.5	7-9	0	Strong consensus (2nd Delphi round)
	4e	Empiric postoperative antibiotic treatment can be employed in PSFBs presenting with polyps, edema, crusting, or purulent discharge and bacterial cultures, and antibiograms are encouraged in cases of suspected secondary CRS or bacterial superinfection	7.89	8	3-9	1	Consensus (2nd Delphi round)
	4f	When post-operative endoscopy demonstrates a widely patent ostia with a normal endoscopic examination, no strict follow-up is required, although a 6- to 24-month postoperative	7.78	8	5-9	1	Consensus (3rd Delphi round)

		endoscopy is desirable in all patients, and a yearly endoscopy might allow early identification of recurrence and secondary sinus ostia closure in high-risk or immunosuppressed patients					
	4g	Post-operative imaging in PSFBs should be limited to cases of possible or ascertained recurrence or complication or in patients where a full endoscopic evaluation of the originally affected sinuses is not allowed by anatomical or post-surgical features	7.83	8	5-9	1	Consensus (2nd Delphi round)

FIGURE LEGENDS

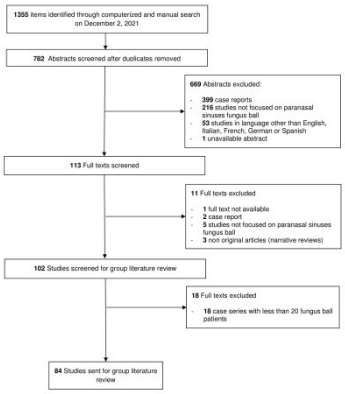

Figure 1 - PRISMA flow chart of the article selection process

SUPPORTING INFORMATION

Supporting information 1 - Search strategy for all consulted databases

Supporting information 2 - Statement evolution along the three Delphi consensus rounds. (blue: strong consensus; green: consensus; yellow: near-consensus; red: no consensus)

Supporting information 3 – Full references detailed with clinical study type, evidence level according to the Oxford Centre for Evidence-based Medicine (OCEBM) level of evidence guide, and patients' pool size for each article circulated among CCS participants and resulting from the systematic review