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INVITED REVIEW
BASIDIOMYCOSIS: A REVIEW OF THE LITERATURE

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SUMMARY

The basidiomycosis, fungal infections provoked by basidiomycetes or agaric fungi have been recorded at growing frequencies in the medical literature, especially after the advent of AIDS in 1991. The basidiospores of these fungi, scattered in the atmosphere and transported by winds or air currents, reach the maxillary sinuses through the nasal route, most of the times causing signs and symptoms of chronic sinusitis. Basidiomycetes have also been isolated from sputum, especially *Schizophyllum commune*. Lesions of the buccal mucosa, brain abscesses, onychomycosis and endocarditis have been described, with a growing interest in this type of deep mycosis on the part of mycologists and infectologists. The present paper reports descriptions of mycetism as well as infectious processes caused by basidiomycetes, such as *Schizophyllum commune*, *Ustilago maydis* (= *Ustilago zeae*) and *Coprinus cinereus*.

KEYWORDS: Basidiomycosis – Review

INTRODUCTION

Basidiomycosis are fungal infections caused by basidiomycetes or agaric fungi that are rarely cited in the medical literature.

After the advent of AIDS in 1981, the number of cases of basidiomycosis has increased. Therefore, we carried out the present review, alerting mycologists and infectologists to this new problem in human pathology. According to RIHS et al.[22] (1996), an increased number of basidiomycetes is being isolated at the CDC in Atlanta (35 strains in 2 years), most of them from the respiratory tract. The clinical significance of these strains is not well established yet because of the lack of histopathological data. At present, with the use of benomyl, a fungistatic agent that selects or recognizes basidiomycetes, mainly *Schizophyllum commune*, the culture media based on this substance will increase the number of isolates of this fungus (16 strains in 2 years, according to RIHS et al.[22], 1996).

Therefore, we are facing new emerging agents that cause, in most cases, sinusitis. Lung lesions, brain abscesses, allergic pulmonary processes, ulcerative lesions of the mucosa and onychomycosis can also be provoked by agaric fungi belonging, according to the general classification of fungi, to the division Basidiomycota. Fungi assigned to this division, called agaric fungi, are frequently used as food and are called edible mushrooms (see enclosed list). Edible fungi are also used in folk medicine in Central America and Mexico. Healers and wizards utilize these organisms as popular remedies. Among them are fungi of the genera *Boletus*, *Calvatia*, *Clitocybe*, *Lactarius*, *Cordyceps*, *Lycoperdon*, *Pleurotus*, *Ustilago* and *Vascellum*. The growing acculturation leads to the disappearance of this thousand-year-old tradition. GUZMÁN (1979)[10], in an excellent review, listed the properties and uses of fungi in folk medicine in Mexico.

Other fungi are toxigenic, producing signs and symptoms of mycetismus. Concerning this subject, fre-

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quently reported in the literature and more of medical and veterinary interest, we only present a summarized general view using the data of SCHVARTSMAN[25] (1992) and RUMACK & SALZMAN[24] (1978). Our current interest is to summarize the lesions caused by the genera *Schizophyllum*, *Coprinus* and *Ustilago*, which are called basidiomycoses, in terms of human and veterinary pathology.

The spores of basidiomycetes (basidiospores) are borne by the wind and inhaled, causing different clinical pictures that are described below.

Edible fungi

Agaricus brunnescens (= *A. bisporus*) (Paris mushroom)
A. campestris var. bisporus
A. bitorquis
Amanita cesarea
Boletus edulis
Coprinus comatus
Lactarius indigo
Lentinus edodes
Flammulina velutipes
Morchella
Pleurotus ostreatus (Shimeji, Japanese)...
Russula brevipes
Tremella fuciformis
Volvariella volvaceae
Tuber (truffles): The best, most appreciated ones are "black truffles" = *Tuber melanosporum*

Toxigenic fungi

Amanita bisporigena
A. muscaria
A. phalloides
A. pantherina
A. verna
Claviceps purpurea (ascomycete)
Inocybe fastigiata
Panaeolus sphinctrinus (coprophilic)
Pleurotus olearinus (luminescent)
Psilocybe cubensis (hallucinogenic)
P. mexicana

Mycetismus

(Data from SCHVARTSMAN[25], 1992, and RUMACK & SALZMAN[24], 1978).

Irrespective of the ingested mushroom the symptoms generally begin with a gastrointestinal picture. The time between the ingestion of the mushroom and the appearance of symptoms is a valuable tool for diagnosis and prognosis. A short latency period, less than 2 h, has a favorable prognosis, while a long latency period, more than 6 h, suggests severe intoxication.

Intoxications with a short latency period:

* Gastrointestinal syndrome:
  Agaricus, *Boletus*, *Russula*, *Paxillus*, *Entoloma*
* Hallucinogenic syndrome:
  Psilocybe mexicana, *Conocybe* sp. (psilocybin), *Paneolus* sp, *Pholiota* sp
* Muscarinic syndrome:
  Inocybe sp, *Boletus* sp, *Hebeloma* sp, *Amanita muscaria* (muscarine). Atropine is the specific antidote.
* Pantherinic syndrome:
  Amanita pantherina, *A. muscaria*
* Coprinus syndrome:
  Coprinus atramentarius (active principle: coprine).

Intoxications with a long latency period:

* Phalloid syndrome:
  Amanita phalloides, *A. verna*, *A. virosa*, *Galerina marginata*. Production of phalloid-type toxins, particularly phalloidine and amatoxins, with amanitin being the most toxic one. Hepatic and renal lesions. Poor prognosis.
* Gyromitra syndrome:
  Gyromitra esculenta (production of gyromitrine).
* Cortinarius syndrome:
  Cortinarius speciosissimus, *C. venenosus*, *C. orellanus*. Interstitial nephritis.

CLASSIFICATION OF BASIDIOMYCETES. GENERAL CHARACTERISTICS

Basidiomycetes comprise the mushrooms, some edible fungi, and other agents causing mycetismus or plant diseases such as the so-called "rust" and "smut" diseases. These fungi possess a septate mycelium with perforated septa such as those found in Ascomycetes. There is a strong tendency of the mycelial cells to become dikaryotic. In some hyphae and in tissues parasitized by basidiomycetes, handles or clamp connections are formed (see Fig. 1).

The main characteristic of this group is the presence of basidia that produce basidiospores. These basidiospores are produced outside the basidia and are generally unicellular and haploid. The formation of these spores is preceded by karyogamy, followed by meiosis.

The fruiting body (basidiocarp) can be several centimeters long and can weigh a few grams.

The basic characteristic of the subdivision Basidiomycotina is the basidium where karyogamy and

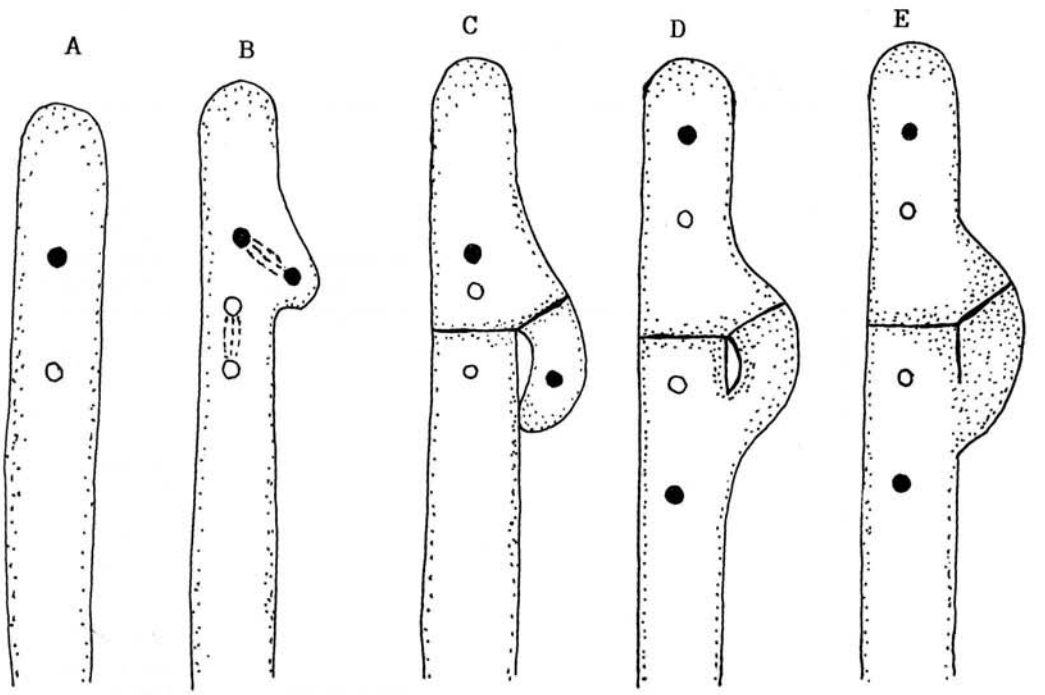

Fig. 1 – Schematic drawing of the formation of the clamp connection. A) Apical region of the dikaryotic hypha; B) simultaneous nuclear division and formation of the lateral branch to which one of the nuclei migrates; C) formation of 2 septa that separate the 2 compatible nuclei in the apical region of the cell and a single one in the lateral branch; D) fusion of the lateral branch by returning to the subapical dikaryotic cell; E) final stage. (According to Hawksworth, D.L.; Kirk, P.M.; Sutton, B.C. & Pegler, D.N. – Ainsworth & Bisby's Dictionary of the Fungi. 8th ed. Oxon, CAB International, 1995.)[11] The clamp connection (= fibula, handle, loop, septum, hyphal clamp) is a characteristic connection of the dikaryotic mycelium of many Basidiomycetes composed of a diverticulum or a small semicircular, pleurogenic channel that projects downwards, bending until it reaches the lower cell of the same hypha to which it unites.

meiosis take place, resulting in the formation of basidiospores which are directly inserted into the wall of the basidium or on its extensions (sterigma).

The term basidium (Fig. 2), according to FIDALGO & FIDALGO[7] (1967), was proposed by GUILLERMIN & LEIVEILLÉ (1837) for sporophore-like structures found in the lamellae of *Agaricus* and in the pores of *Boletus*. The basidia are present in different forms, frequently clavate, septate or continuous and with sterigmata and forming the mother cells of the basidiospores. Initially dikaryotic, as a result of karyogamy (fusion of nuclei) and meiosis (double division), the mother cells subsequently give origin to 4 haploid nuclei that migrate to the tip of the projections called sterigmata. The basidiospore is surrounded by 3 layers.

Two large classes characterize the subdivision Basidiomycotina: Heterobasidiomycetes and Holo- or Homobasidiomycetes. In the Heterobasidiomycetes (LINDER, 1946) or Phragmobasidiomycetes, the basidia are furcated and the septa are arranged transversely. In the Holobasidiomycetes or Homobasidiomycetes, a term proposed by VAN TIEGHEM in 1893, the basidium is continuous, and furcated or not furcated. Basidiocarps are the fruiting bodies of Basidiomycetes, also called carpophores, which bear or support the basidia, small pedestals.

Basidiomycotina *(Table 1)*

A – Macroscopic basidiomas are present, but disappearing; the basidia are arranged in a hymenium.

a) Hymenomycetes: The basidiocarp is typically a gymnocarp or semi-angiocarp; the basidiospores are ballistospores.
b) Gasteromycetes: The basidiocarp is typically an angiocarp; the basidiospores are not of the ballistospore type.

B – Macroscopic basidiomas are absent; yeast-like states are present or absent.

a) Urediniomycetes: Teliospores (uredinospores), promycelium and sporidia are present, as well as sexual organs. These fungi cause rust on cereals. The mycelium has no clamp connection.
b) Ustilaginomycetes: Teliospores (ustilospores), promycelium and sporidia are present. Species of the genus *Ustilago* cause smut on corn, oats and wheat.

TABLE 1

Subdivision Basidiomycotina (According to HERRERA & ULLOA[12], 1990)

CLASS	SUBCLASS	ORDER	FAMILY	GENUS
Heterobasidiomycetes		Uredinales	Pucciniaceae	*Gymmnosporangium*
				Hemileia
				Phragmidium
				Puccinia
				Uromyces
			Melampsoraceae	*Cronartium*
			Coleosporiaceae	*Coleosporium*
		Ustilaginales	**Ustilaginaceae**	*Aessosporon*
				Farysia
				Filobasidiella
				Filobasidium
				Rhodosporidium
				Sphacelotheca
				§ ***Ustilago***
			Tilletiaceae	*Entorrhiza*
				Entyloma
				Tilletia
				Urocystis
			Graphiolaceae	*Graphiola*
		Tremellales	Dacrymycetaceae	*Calocera*
				Dacrymyces
				Dacryopinax
			Tremellaceae	*Ductifera*
				Exidia
				Phlogiotis
				Pseudohydnum
				Tremella
			Auriculariaceae	*Auricularia*
				Eocronartium
				Helicobasidium
				Jola
			Septobasidiaceae	*Septobasidium*
			Tulasnellaceae	*Metabourdotia*
				Pseudotulasnella
				Tulasnella
			Ceratobasidiaceae	*Ceratobasidium*
Holobasidiomycetes	Hymenomycetidae (hymenomycetes)	Exobasidiales	Exobasidiaceae	*Exobasidium*
		Brachybasidiales	Brachybasidiaceae	*Brachybasidium*
				(= Kordyana)
		Agaricales	Boletaceae	*Boletus*
				Strobilomyces
				Suillus
				Tylopilus
				Xerocomus
			Russulaceae	*Lactarius*
				Russula
			Coprinaceae	§ ***Coprinus***
				Panaeolus
			Agaricaceae	*Agaricus*
			Lepiotaceae	*Chlorophyllum*
				Lepiota
				Leucoagaricus
				Macrolepiota
			Rhodophyllaceae	§ ***Clitopilus***
				Entoloma
				Rhodophyllus
			Volvariaceae	*Volvariella*
			Cortinariaceae	*Cortinarius*

TABLE 1

Subdivision Basidiomycotina (According to HERRERA & ULLOA[12], 1990) – (cont.)

CLASS	SUBCLASS	ORDER	FAMILY	GENUS
				Galerina
				Hebeloma
				Inocybe
			Strophariaceae	*Agrocybe*
				Kuehneromyces
				Naematoloma
				Pholiota
				Psilocybe
				Stropharia
			Hygrophoraceae	*Hygrocybe*
				Hygrophorus
			Amanitaceae	*Amanita*
				Amanitopsis
			Tricholomataceae	*Armillariella*
				Clitocybe
				Collybia
				Cortinellus
				Flammulina
				Laccaria
				Lentinus
				Lepista
				Lyophyllum
				Marasmius
				Melanoleuca
				Mycena
				Omphalotus
				Oudemansiella
				Pleurotus
				Tricholoma
		Aphyllophorales (= Polyporales)	Clavariaceae	*Clavaria*
				Clavariadelphus
				Clavicorona
				Clavulina
				Ramaria
			Schizophyllaceae	§ ***Schizophyllum***
			Corticiaceae*	*Corticium*
				Peniophora
				Trechispora
			Sparassidaceae*	*Sparassis*
			Stereaceae*	*Stereum*
			Cantharellaceae	*Cantharellus*
				Gomphus
			Hydnaceae	*Auriscalpium*
				Dentinum
				Echinodontium
				Hericium
				Hydnum
				Sarcodon
			Polyporaceae	*Amauroderma*
				Coniophora
				Coriolus
				Daedalea
				Fomes
				Ganoderma
				Gloeophyllum
				Heterobasidion
				Hexagonia
				Irpex

TABLE 1
Subdivision Basidiomycotina (According to HERRERA & ULLOA[12], 1990) – (cont.)

CLASS	SUBCLASS	ORDER	FAMILY	GENUS
				Laetiporus
				Lenzites
				Merulius
				Polyporus
				Polystictus
				Poria
				Pycnoporus
				Serpula
				Spongipellis
				Ungulina
	Gasteromycetidae (Gasteromycetes)	Hymenogastrales	Hymenogastraceae	*Hymenogaster*
				Rhizopogon
			Secotiaceae	*Endoptychum*
				Montagnea
				Secotium
		Podaxales	Podaxaceae	*Podaxis*
		Lycoperdales	Lycoperdaceae	*Bovista*
				Calvatia
				Lycoperdon
				Vascellum
			Geastraceae	Geastrum
		Sclerodermatales	Sclerodermataceae	*Pisolithus*
				Scleroderma
			Astraeaceae	*Astraeus*
				Myriostoma
		Tulostomatales	Calostomataceae	*Calostoma*
			Tulostomataceae	*Battarraea*
				Battarreoides
				Tulostoma
		Nidulariales	Nidulariaceae	*Crucibulum*
				Cyathus
				Nidula
				Nidularia
			Sphaerobolaceae	*Sphaerobolus*
		Phallales	Clathraceae	*Clathrus*
				Linderia
				(= *Colonnaria*)
			Phallaceae	*Dictyophora*
				Mutinus
				Phallus

* Previously considered to be one family: Thelephoraceae.
§ Basidiomycetes reported so far to be agents of basidiomycosis.

General characteristics

Species of the subdivision Basidiomycotina are unicellular or filamentous fungi possessing a septate mycelium with or without handles (clamp connections). Reproduction can be asexual through conidia or sexual through exogenous basidiospores that are generated in the basidia. In the former class Teliomycetes, that currently includes the classes Urediniomycetes (Uredinales) and Ustilaginomycetes (Ustilaginales), teliospores with or without promycelium and sporidia are found.

Registration of cases

The following basidiomycetes have been considered to be responsible for human lesions and processes of hypersensitivity:

1. *Schizophyllum commune* Niederpruem et Wessels, 1969
   Systematic classification – Basidiomycotina; Homobasidiomycetes (= Holobasidiomycetes); Aphyllophorales (= Polyporales); Schizophyllaceae; *Schizophyllum*.

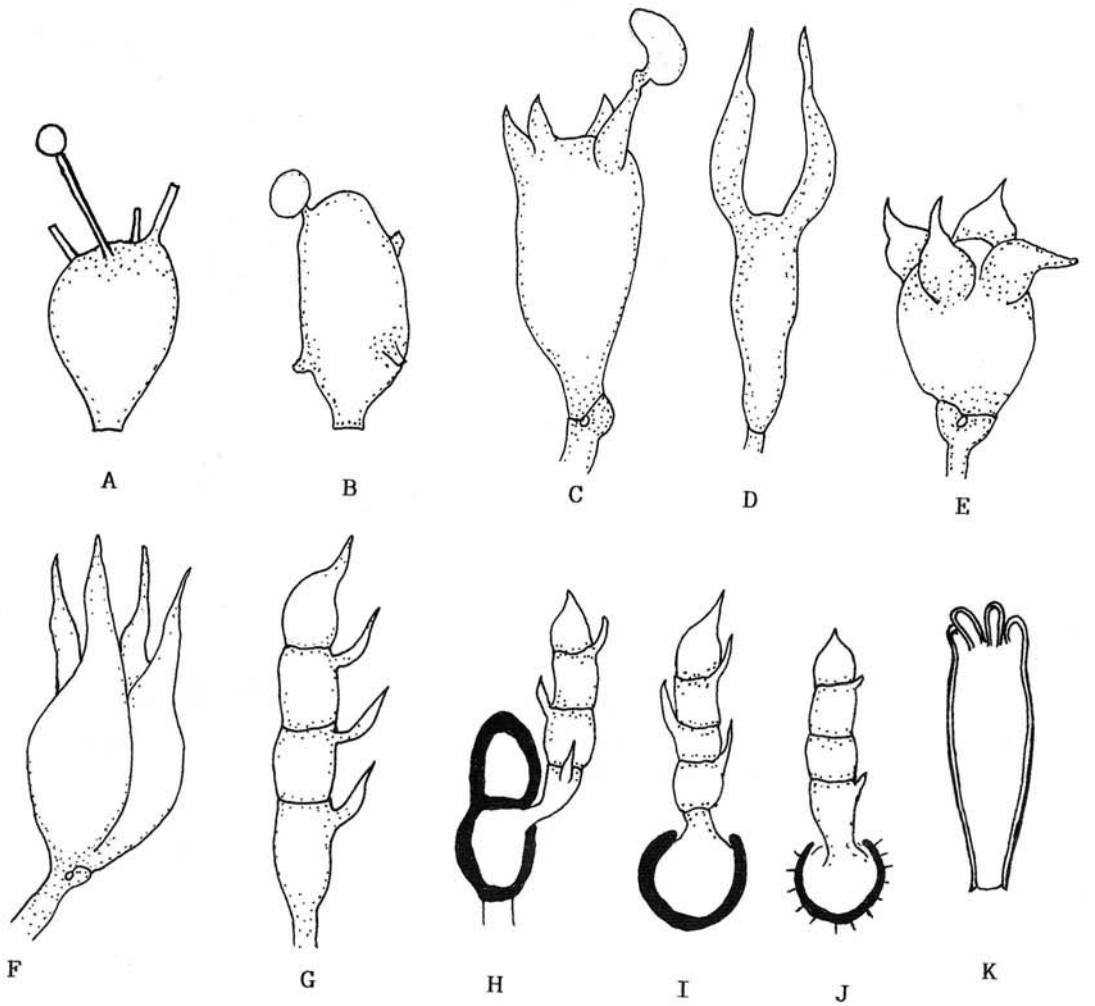

Fig. 2 – Types of basidia. 1) Holobasidium (A-E): a) Apobasidium (A, Lycoperdales; B, Tulestomatales; b) Autobasidium (C, Agaricales; D, Dacrymycetales; E, Tulasnellales. 2) Phragmobasidia (F-K): a) Basidiomycetes (F, Tremellales; G, Auriculariales); b) Teliomycetes (H, Uredinales; I, Septobasidiales); c) Ustomycetes (J, Ustilaginales; K, Cryptobasidiales). (According to Hawksworth, D.L.; Kirk, P.M.; Sutton, B.C. & Pegler, D.N. – Ainsworth & Bisby's Dictionary of the Fungi. 8th ed. Oxon, CAB International, 1995)[11].

2. *Coprinus cinereus* Grey, 1821
   Systematic classification – Basidiomycotina; Homobasidiomycetes (= Holobasidiomycetes); Agaricales; Coprinaceae; *Coprinus*.
3. *Ustilago zeae* Schweinitz, 1822 (= *U. maydis* Corda, 1842). In 1815, De Canholle named this fungus *Uredo maydis*.
   Systematic classification – Basidiomycotina; Heterobasidiomycetes; Ustilaginales, Ustilaginaceae, *Ustilago*.
4. *Clitopilus septicoides* Kummer, 1871
   Systematic classification – Basidiomycotina; Homobasidiomycetes (= Holobasidiomycetes); Agaricales; Rhodophyllaceae; *Clitopilus*.

Schizophyllum commune Niederpruem et Wessels, 1969 was identified by ROSENTHAL et al.[23] (1992) in HIV-positive patients in material collected from the maxillary sinus (a case of sinusitis). The same basidiomycete was isolated from a pulmonary fungus ball by

SIGLER et al.[26] (1995). In 1971, RESTREPO et al.[21] reported a case of perforated ulceration of the mucosa caused by *Schizophyllum commune* in a 4-year old girl presenting lesions of the hard palate. After treatment with amphotericin B the process regressed, with the persistence of some neurological manifestations which were previously present in the patient. Histopathological examination revealed filaments with handles or "clamp connections". The material from this case was studied by GREER & BOLANOS[9] (1971) and GREER[8] (1978).

Schizophyllum commune degrades wood. Most of the data on this fungus are reported in the study of WATLING & SWEENEY[29] (1974). In 1986, KERN & UECKER[15] reported two cases of maxillary sinusitis caused by *Schizophyllum commune* (medusoid variant). According to these investigators, the rare cases of this infection may reflect impairment of the immunologic status of the host by antibiotics or corticoids.

KAMEI et al.[14] (1994) reported a case of allergic bronchopulmonary basidiomycosis caused by *Schizophyllum commune* presenting fungal hyphae and clamp connections and specific IgE in the serum. Basidiocarps were obtained by bronchoscopy. KLIGMAN[16] (1950) reported a case of onychomycosis provoked by *Schizophyllum commune*. MARLIER et al.[17] (1993) isolated a strain of *Schizophyllum commune* from a homosexual patient with chronic maxillary sinusitis. The patient died presenting symptoms of lymphocytic meningoencephalitis. SUMMERBELL[28] (1993), cultivating fungi with 3 different concentrations of benomyl, a well-known fungicide, showed that basidiomycetes and zygomycetes are not inhibited by this substance. Thus, this fungicide may select certain fungal species. According to SUMMERBELL[28] (1993), over three years of laboratory routine, no basidiomycete was found to be sensitive to a concentration of 10 µg/ml of benomyl.

RIHS et al.[22] (1996) reported a case of cerebral abscess caused by *Schizophyllum commune* after the use of corticoids. Histopathological examination of the biopsied pulmonary lesion, in the form of a mass with a tumoral aspect, revealed the presence of hyphae compatible with the diagnosis of aspergillosis. Treatment with amphotericin B and itraconazole was begun. During the course of therapy the patient presented a lesion in the left parietal lobe. After a biopsy, the anatomopathological examination was consistent with the diagnosis of aspergillosis. However, septate hyaline hyphae of different diameter with clamp connections were still found in both brain and lungs and cultures were positive for *Schizophyllum commune*.

RIHS et al.[22] (1996) reported that an increased number of basidiomycetes is being isolated at the CDC (35 isolates in 2 years), most of them cultures from pulmonary lesions. Chronic sinusitis caused by *Schizophyllum commune* has also been reported. Amphotericin B is active *in vitro* against *Schizophyllum commune* and the fungus is also inhibited by cycloheximide. RIHS et al.[22] (1996) referred to a culture technique based on Sabouraud agar containing 10 µg/ml benomyl which facilitates the growth of the fungus. CHAVES-BATISTA et al.[1] (1955) reported the isolation of a basidiomycete from cerebrospinal fluid identified as *Clitopilus septicoides*. The patient presented with a picture of intracranial hypertension. According to RIHS et al.[22] (1996), this fungus should be classified as *Schizophyllum commune*. The same fungus has been isolated from sputum by CIFERRI et al.[2] (1956).

SPELLER & MacIVER[27] (1971) reported a case of endocarditis caused by a basidiomycete of the genus *Coprinus* which was identified as *Coprinus lagopus* Brefeld, 1877, initially possessing sclerotia; later the identification revealed *Coprinus cinereus* Grey, 1821. This species is found in decomposing plant matter and some species are coprophilic.

Initially, the case reported by SPELLER & MacIVER[27] (1971) was considered to be provoked by

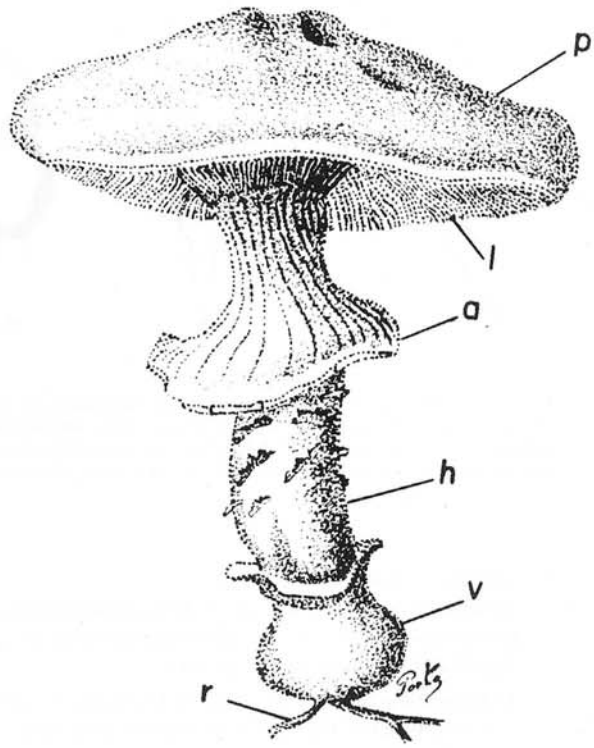

Fig. 3 – Schematic drawing of the fruiting body of basidiomycetes. p – Pileus, with an umbonate or **estipitado** profile and expanded in shape; l – lamellae; a – ring; h – stalk; r – rhizoid; v – volva. (According to E. Porto).

Streptococcus viridans. After ineffective antibiotic therapy, the mitral valve of the patient was replaced with a Beale prosthesis. Later, the patient received a Starr-Edwards prosthesis replacing the aortic valve, but he died. After autopsy, the material of the aortic valve, that presented obvious alterations, was cultured on blood agar and peptone-dextrose agar at 29 and 37°C for 48 h. No bacterial growth was observed on blood agar. On peptone-dextrose agar, at 29 and 37°C, the fungus grew well producing a dense, white mycelium with a felt-like texture, and elevated and furrowed colonies. The back of the colony showed a yellow-opaque to light-rosy shade. Spores were formed in these colonies in the center of the culture and, after two months, a large number of globular and egg-shaped, dark-brown sclerotia were produced. These sclerotia contain cells with an extremely thick cell wall similar to those of the cells of the Hülle found in some *Aspergillus* species. The fungus was cultivated in several media. Slide cultures grown on potato saccharose agar and subsequently stained with cotton-blue were examined microscopically. The following morphological characteristics were noted: cylindric, hyaline conidia originating from short and branched conidiophores. The conidia were clustered at the apices of the conidiophores due to drops of viscous liquid. The tips of the conidiophores were widened, with 2 to 5 finger-like cells originating from them, having the same diameter but presenting twice the length. The fungus was identified by de VRIES in the Netherlands (Centraalbureau voor Schimmelcultures) as a conidial stage of *Coprinus* sp, on the basis of its morphological similarity to *Coprinus lagopus*. The isolated strain was examined to establish its sensitivity to antifungal agents. The fungus was inhibited by amphotericin B at a concentration of 0.25 µg/ml, but was not sensitive to 5-fluorocytosine at a concentration of more than 250 µg/ml.

COONEY & EMERSON[3] (1964), studying thermophilic fungi, noted that only basidiomycetes, including the species of the genus *Coprinus*, are thermotolerant. Some *Coprinus* species are coprophagous while others grow on decomposing plant matter. *Coprinus* species have a monokaryotic conidial shape, rarely producing fruiting bodies (basidiocarps), and exactly in this form the fungus was isolated from a patient with endocarditis. SPELLER & MacIVER[27] (1971) concluded that the fungus studied is more related to *Coprinus delicatulus* than to *Coprinus lagopus*. The conidia of *C. lagopus* can be ingested by insects.

DE VRIES et al.[5] (1971) reported a case of endocarditis affecting the mitral valve which was replaced with a prosthesis. Fungal vegetation had developed on the material of the prosthesis from which a sample of *Coprinus* was isolated, initially identified as *C. delicatulus* Apinis, 1965. This basidiomycete was inhibited by amphotericin B at a concentration of 0.25 µg/ml. At present, *C. delicatulus* seems to be identical to *Coprinus cinereus*.

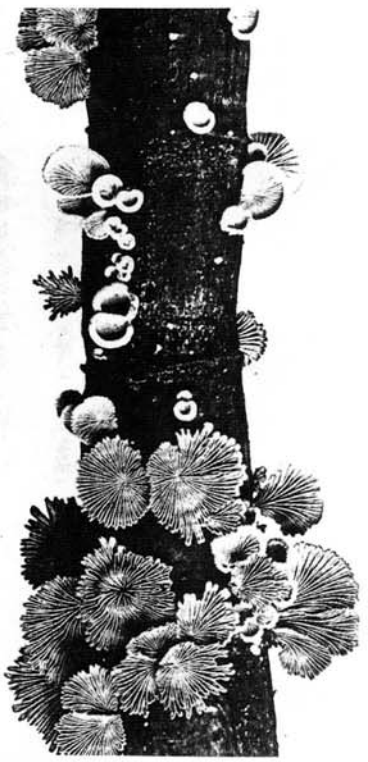

Fig. 4 – *Schizophyllum commune*. Sporophores growing naturally on a decomposing branch. Photograph by Dr. John A. Stevenson (In: Kligman, A.M. – A basidiomycete probably causing onychomycosis. **J. invest. Derm., 14:** 67-70, 1950)[16].

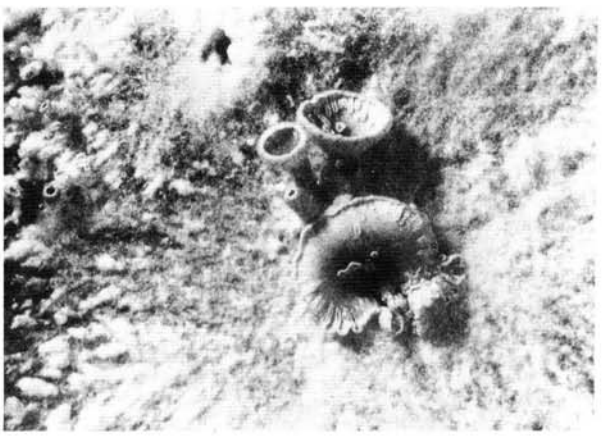

Fig. 5 – *Schizophyllum commune* isolated from the material of the left maxillary sinus of an HIV-positive patient. (According to Rosenthal, J.; Katz, R.; Dubois, D.B.; Morrissey, A. & Machicao, A. – Chronic maxillary sinusitis associated with the mushroom *Schizophyllum commune* in a patient with AIDS. **Clin. infect. Dis., 14:** 46-48, 1992)[23].

EMMONS[6] (1954) reported the repeated isolation of a basidiomycete from the sputum of a patient that was identified as *Coprinus micaceous*, but he did not provide any information about the participation of this fungus in the pulmonary picture. A case of rhinitis and asthma caused by sensitization to spores of *Ustilago* sp was described by OLIVEIRA LIMA[19] (1952) involving a worker at a wheat mill after 5 years of continual work in a contaminated environment. Specific hyposensitization permits the control of the allergic process. The first case of ustilaginism described was a dermatomycosis possibly caused by *Ustilago maydis*, which seems to be synonymous with *Ustilago zeae* described by PREININGER[20] (1937-1938). The patient worked on a corn plantation under the hot sun and at night he fell asleep outdoors and was drenched in the rain staying with wet clothes overnight. When the patient was examined he presented lesions on the skin in the areas that had been in contact with his wet clothes. These lesions consisted of infiltrated and hyperemic plaques on the thorax, back, arms, inguinal regions, legs, armpits, neck, elbows and on the back of the feet. Red papulae were noted on the chest, legs and buttocks. Hyperkeratosis on the palms and soles was observed which became lamellar with infiltration of the dermis. Microscopic examination of scrapings from the skin of different parts of the body revealed the presence of spores identical to those found on corn leaves showing fuliginous or black areas, collected in the corn field where the patient had worked. This cutaneous disease was first provoked by a fungus from corn soot or smut isolated, cultivated and identified as *Ustilago zeae* (*U. maydis*).

The second case of human infection caused by *Ustilago zeae* (*U. maydis*) was recorded by MOORE et al.[18] (1946). In this case the brain was involved and the patient presented with a picture of leptomeningitis and ependymitis. The patient reported that he had felt dizzy and sick, with headache and vomiting for two years. When he was submitted to cerebellar craniotomy, no tumor was found, and therefore the case was diagnosed as chronic cystic arachnoiditis. After improving, the patient continued working on the corn plantation. Later, alterations in memory, reasoning, vision and audition appeared, with the occurrence of right lateral nystagmus and the patient died. Autopsy revealed macroscopic alterations in the lungs, trachea and bronchi which showed hyperemic characteristics with the presence of mucus. The brain also showed some alterations which did not occur in the liver, spleen, kidneys or gastrointestinal tract. A chronic infection was not suspected, especially caused by a fungus in the brain, considering the low opacity and thickening of the leptomeninges. The entire brain was fixed with formaldehyde which made it impossible to isolate and cultivate the fungus.

The order Ustilaginales includes hundreds of species that parasitize higher plants. MOORE et al. (1946)[18] classified the spores found in the parasitized tissues in

Fig. 6 – *Schizophyllum commune*. Appearance of a colony on Czapek agar after 14 days at 25°C showing fruiting bodies. (According to Ribs, J.D.; Padhye, A.A. & Good, C.B. – Brain abscess caused by *Schizophyllum commune*: an emerging basidiomycete pathogen. **J. clin. Microbiol., 34:** 1628-1632, 1996)[22].

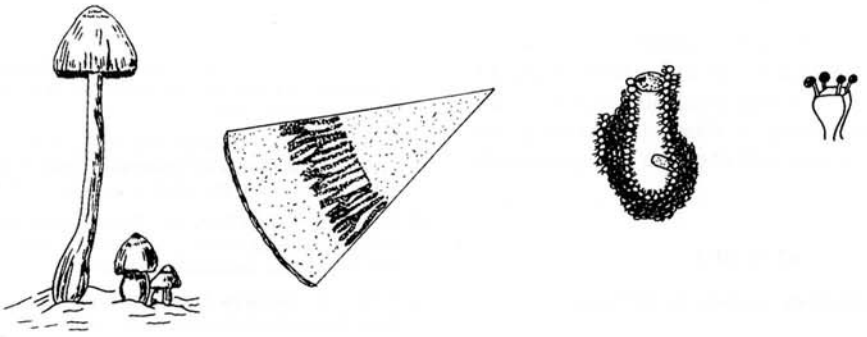

Fig. 7 – *Coprinus* spp. General appearance of 3 basidiocarps at different developmental stages. The last drawing on the right shows a stylized holobasidium. In: Joly, A.B. – Botanica. Introdução a taxonomia vegetal. 2. ed. São Paulo, Companhia Editora Nacional e Editora da Universidade de São Paulo, 1975[13].

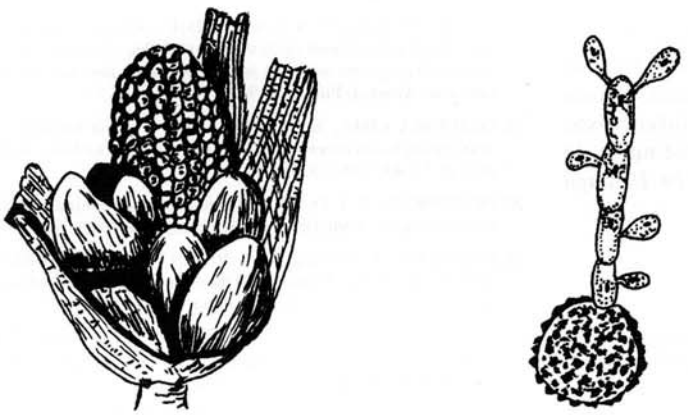

Fig. 8 – *Ustilago* sp – Attacked corn ear showing the asci (smut). On the right, germinating spores with 4 hypobasidia and 5 basidiospores. In: Joly, A.B. – Botanica. Introdução a taxonomia vegetal. 2. ed. São Paulo, Companhia Editora Nacional e Editora da Universidade de São Paulo, 1975[13].

terms of shape, size and other morphological characteristics in a comparative study between different types of spores from species of the genera *Tilletia* and *Ustilago*. The authors concluded that, in this case, the fungus causing the cerebral infection was *Ustilago zeae*.

In plants, *Ustilago zeae* produces a fuliginous, black "tumor" covered with a membrane that surrounds the content of the dust-like spores. When the membrane bursts, the spores are blown away by wind or fall to the ground contaminating the site. The mature spores measure 7 to 12 µm in diameter and are spherical, ellipsoid or irregular in shape, and the cell membrane (episporium) is thorny and dark-brown in color.

Ustilago species, called smuts or bunts, are parasites of higher plants and their spores have a black coloration. In some countries this species causes great damage to cereal plantations (mainly wheat and corn).

DIAGNOSIS

Histopathological diagnosis is made by the demonstration of septate or non-septate hyphae with perforated septa and clamp connections or handles which are also called fibula, loop, septum or hyphal clamp. This structure is a characteristic connection of the dikaryotic mycelium of many Basidiomycetes composed of a diverticulum or a small semicircular, pleurogenic channel that projects downwards, bending until it reaches the lower cell of the same hypha to which it unites (Fig. 1). Cultivation on Sabouraud agar containing chloramphenicol and cycloheximide (0.5 mg/ml) and Sabouraud agar containing 10 µg benomyl/ml permits the isolation of the fungus. The cultures should be incubated at 25°C in the dark for 14 days. Besides the presence of fruiting bodies, also present in Czapek agar, slide cultures permit the detection of filamentous mycelium with clamp connections.

TREATMENT

Schizophyllum commune is sensitive *in vitro* to amphotericin B (0.03 µg/ml) and fluconazole (8 µg/ml) when the minimal inhibitory concentrations are determined. Surgical treatment, i.e. removal and debridement of the lesions, is the approach of choice depending on the clinical picture.

RESUMO

Basidiomicoses: revisão da literatura

As basidiomicoses, infecções fúngicas provocadas por basidiomicetos ou agáricos vêm sendo registradas cada vez com maior frequência na literatura médica, principalmente após o advento da AIDS/SIDA, em 1981. Os basidiosporos desses fungos, espalhados na atmosfera e veiculados através do vento ou de correntes aéreas, atingem por via nasal os seios maxilares, provocando quadros de sinusite crônica, na maioria das vezes. Do escarro também têm sido isolados basidiomicetos, principalmente o *Schizophyllum commune*. Lesões da mucosa da boca, abscessos cerebrais, onicomicoses e endocardites já foram descritas, aumentando o interesse dos micologistas e infectologistas para este tipo de micose profunda. O presente trabalho assinala, ao lado dos quadros de micetismo, processos infecciosos provocados por basidiomicetos, a exemplo do *Schizophyllum commune, Ustilago maydis (= Ustilago zeae)* e *Coprinus cinereus*.

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