





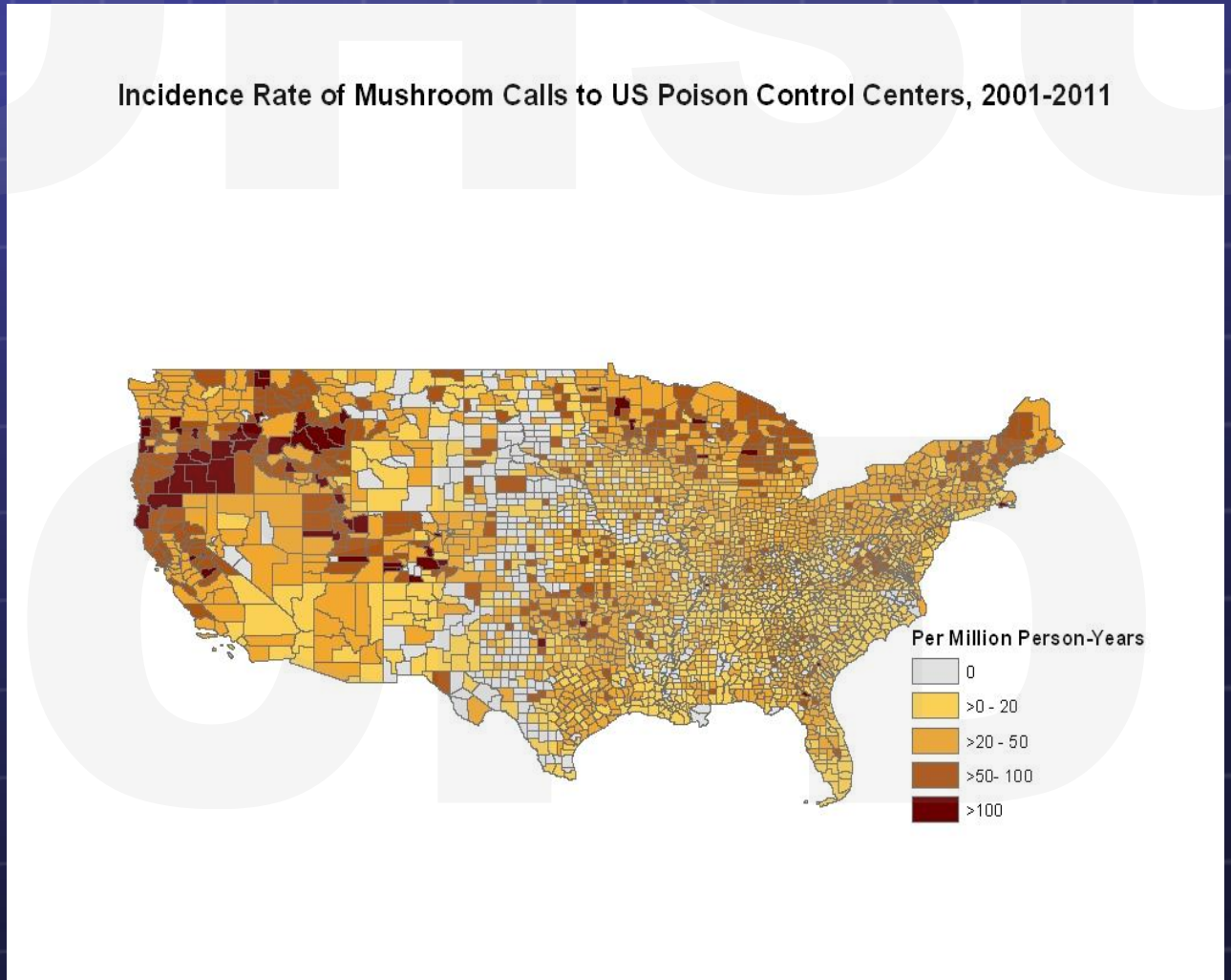
The Three Amanitas

B. Zane Horowitz, M.D. FACMT
Oregon Poison Center

Amanita Species



Total Poison Center Mushroom Calls



THE NEW YORKER

THE MUSHROOM HUNTERS

An edible-gold rush.



By Burkhard Bilger August 13, 2007

Two hours east of Eugene, Oregon, in the rain shadow of the southern Cascades, the forests begin to thin out. The volcanic peaks that loom above them are among the most active on the continent, and every so often one of them blows. The Klamath Indians still talk about the eruption of Mt. Mazama, seven and a half thousand years ago. It left a hole in the ground which is now called Crater Lake and covered the area in pumice up to three hundred feet deep. The ash still lies so thick that logging trucks send great plumes of it trailing behind them, and even old-growth trees have the spindly half-starved look of battlefield survivors. It's the kind of land that only a mushroom could love.

When Kouy Loch first arrived, on a chilly September night in 1994, he was looking for matsutake. The mountains were filled with them, he'd heard. They grew beneath the pines in the national forest—some of the most valuable mushrooms in the world—and anyone with a ten-dollar day pass could pick them. Loch's cousin Saraong, a veteran picker from Washington,

Acute Renal Failure Associated with Suspected *Amanita smithiana* Mushroom Ingestions: A Case Series

CRAIG R. WARDEN, MD, MPH, DENIS R. BENJAMIN, MB, BCH




AMANITA SMITHIANA

Mt. Rainier Foragers

- 74 y.o. Husband & Wife ate 3 mushrooms each while looking for "matsutake" mushrooms
- Nausea & Vomiting at 6 - 12 hours
- Noticed change in urine on day 2 – 3

What is the mushroom toxin ?

What labs would you expect?

American Matsutake
(*Tricholoma murrillianum*)



Foraging for Matsutake a.k.a. Pine Mushroom





Initial Labs Presenting Day 6

Husband

- LDH 1131
- AST 14
- ALT 33
- BUN 81
- Cr 13
- Bicarb 21

Wife

- LDH 1327
- AST 65
- ALT 84
- BUN 91
- Cr 12
- Bicarb 20

OHSU CPD


AMANITA SMITHIANA

Amanita smithiana

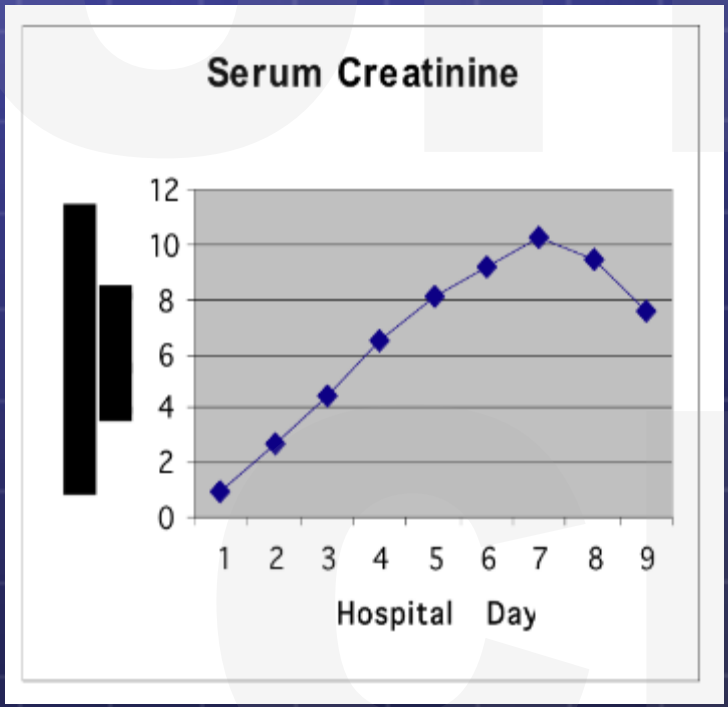
Grows in Pacific NW & British Columbia

- Renal failure occurring 1 to 4 days after ingestion
- Early transient mild elevation LFTs
- Toxin : allenic norleucine toxins :

  pentynoic & hexadienoic acids

Amanita smithiana Mushroom Ingestion: A Case of Delayed Renal Failure and Literature Review

Patrick L. West, MD[a], Janet Lindgren[b], B. Zane Horowitz, MD[a]



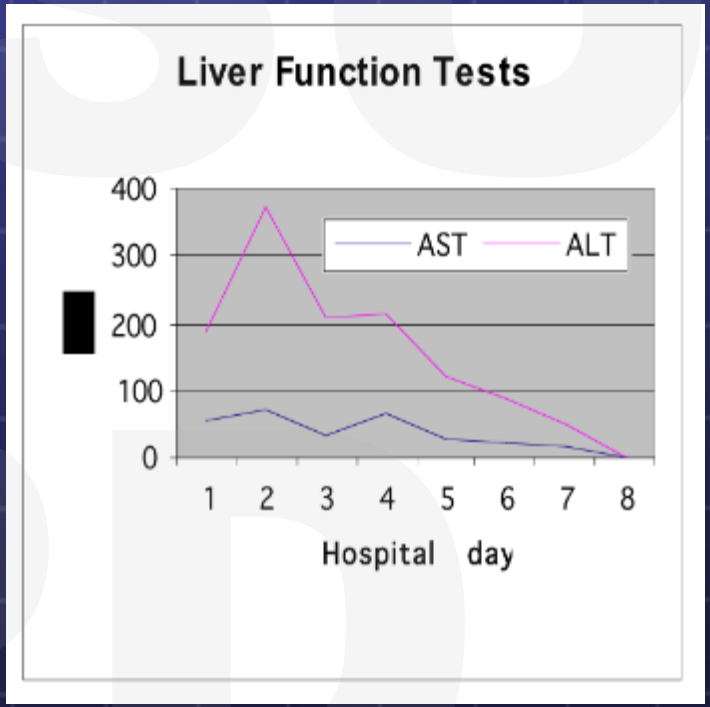


Table 1: *A smithiana* literature review: Presentation and presenting lab values

Reference Number	Pt Data (age, sex)	Symptom Onset	Initial Symptoms	Time to Present	BUN/Cr (mg/dL)/(mg/dL)	Presenting LFTs (U/L)
#2 [9]	43, F	2 hrs	urinary freq, lacrimation, vomiting, oliguria	4 days	60/9 (estimate)	AST 21
#1 [11]	31, F	8 hrs	N/V/D/Abd pain x 7 days	6 days	48/13.2	AST nl, ALT 105, LDH 1392
#2 [11]	49, M	6 hrs, indig, 9 hrs severe	N/V	5 days	87/14.9	AST nl, ALT 103
#3 [11]	64, M	5 hrs	N/V/Abd pain/polyuria.. Anuria at day 2	4 days	126/16.29	AST nl, ALT 129, LDH 1924
#4 [11]	73, M	5 hrs	N/V/Abd pain/polyuria/ D/sweating/dizziness	1 day	18/2.4	AST 223, ALT nl
#1 [10]	no data	10 hrs 45 min	Abd pain/anxiety	no data	no renal failure	no data
#2 [10]	no data	"within a week"	no data	no data	no renal failure	no data
#3 [10]	no data	8 hrs	N/V	no data	hepatic and renal failure	no data
#4 [10]	no data	4 hrs	V/Abd pain, DISCHARGED	returned day 3	renal failure	no data
#5 [10]	no data	10.5 hrs	V/D/sweats/dizzy	no data	renal failure day 2–3	no data
#1 [12]	74, M	6 hrs	N/V/D/anorexia/dec UOP	6 days	81/12.9	AST 14, ALT 33, LDH 1131
#2 [12]	74, F	12 hrs	Abd cramps/V x 24 hrs, then oliguria on day 3–4	6 days	91/12.0	AST 65, ALT 84, LDH 1327
#3 [12]	30, F	20–30 min	Abd cramps/N/V	1 day, 4 days	72/12.2	AST 15, ALT 13, LDH 1459
#4 [12]	55, M	2 hrs	N/sweats/dizzy, V next am	5 days	74/13.9	AST 32, ALT 179, LDH 260

N = nausea, V = vomiting, D = diarrhea, Abd = abdominal

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BRIEF COMMUNICATION

Laboratory confirmation of *Amanita smithiana* mushroom poisoning

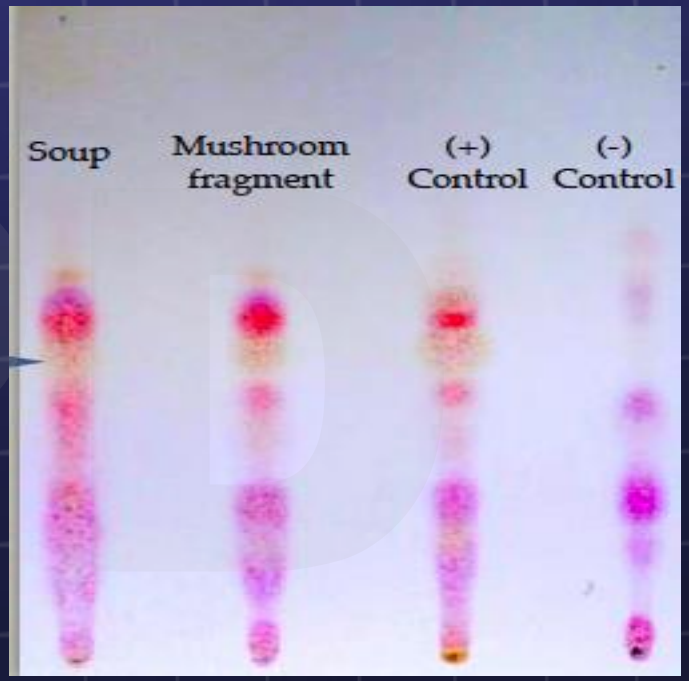
S. APPERLEY[1], P. KROEGER[2], M. KIRCHMAIR[3], M. KIAII[1,4], D. T. HOLMES[5], and I. GARBER[5]

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[2]*Vancouver Mycological Society, Vancouver, BC, Canada*
[3]*Institute of Microbiology, Leopold-Franzens-University of Innsbruck, Austria*
[4]*Division of Nephrology, Department of Medicine, St. Paul's Hospital Vancouver, BC, Canada*
[5]*Department of Pathology and Laboratory Medicine, University of British Columbia, Vancouver, BC, Canada*

British Columbia Lab group :

Developed a Time-of-flight assay
Confirmed by comparison with TLC/MS

Also verified norleucine in Amanita proxima



Allenic Norleucine group

- *Amanita smithiana* (US)

- *Amanita proxima* (France)

JAPAN:

- *Amanita abrupta*
- *Amanita solitaria*
- *Amanita pseudoporphyria*

PORTUGAL:

- *Amanita boudieri*
- *Amanita gracilior*
- *Amanita echinocephala*

Related *Amanita* mushrooms in Europe

- Several European mushrooms cause a similar poisoning syndrome:



Amanita ovoidea



Amanita proxima

Related *Amanita* mushrooms in Europe

- Several European mushrooms cause a similar poisoning syndrome:



Amanita boudieri

(Nephrotoxic - case in Portugal)



Amanita solitaria (echinocephala)

(Nephrotoxic - case in Germany)

Amanita neoovidea (China)

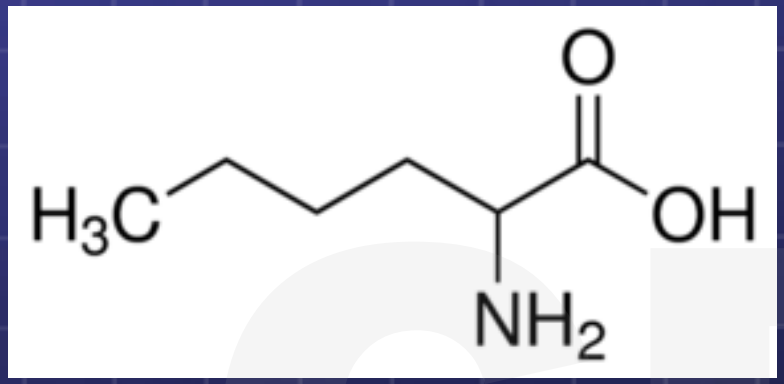




Amanita abrupta (Japan)



Norleucine Pharmacology



- Demethylated Leucine
- Mechanism of action : UNKNOWN !

Amanita Smithiana Treatment

- Supportive care
- Aggressive fluid resuscitation
- Monitor for 1 week (BUN/ CR, I's & O's)

  may need hemodialysis if AKI/ ARF

Amanita Phalloides



Columbia River Foragers

- 5 people ingest 60 to 100 wild mushrooms found in the gorge.
- They were looking for the "paddy straw" mushroom (*Volariella volvaces*) under chestnut trees.
- 7 – 10 hours: crampy abdominal pain, vomiting followed by profuse watery diarrhea.
- Initial ED labs – all normal

Look alikes

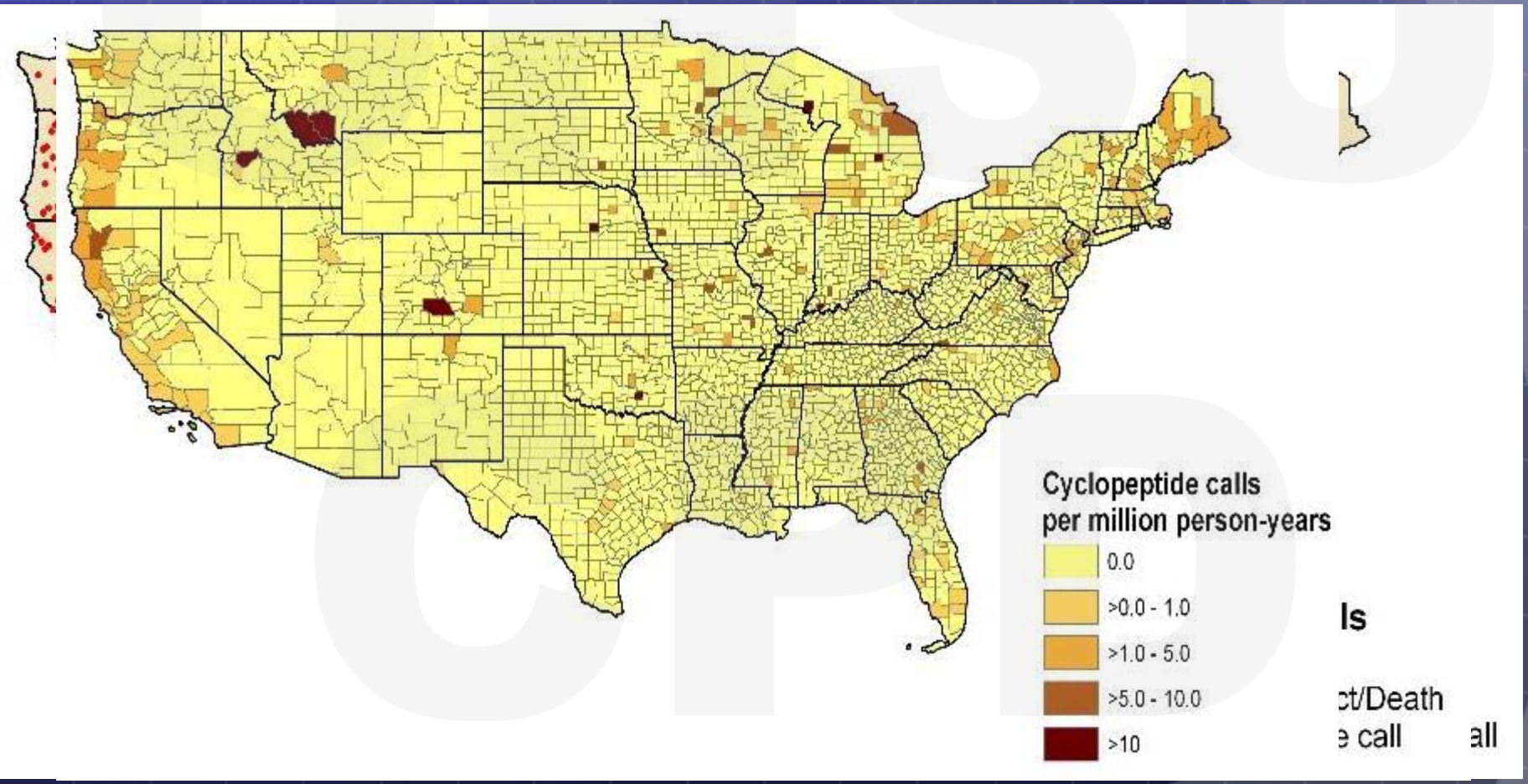


Volariella volvaces



Amanita bisporogera

Group 1: Cyclopeptide



Five Foragers

Liver Labs:

- AST 4600
- Ammonia 105
- Bilirubin 12
- PT 81

Renal Function:

- BUN 3
- Cr 0.8
- Bicarb 16
- Phosphate 0.8

Five Foragers

4 patients develop:

- Hepatic encephalopathy
  - Hypoglycemia in 2 despite IV dextrose
- Coagulapathy and GI bleeds (despite FFP transfusion)
- Hepatic transplantation
- Profuse diarrhea continues post-TX

Poisoning in Pacific NW

5 survive in Oregon

The five people poisoned with death cap mushrooms in Oregon in October hadn't even gone out looking for mushrooms, but were gathering chestnuts. Two of the five were from Korea, and they thought the *Amanita phalloides* they stumbled onto were paddy straw mushrooms, *Volvariella volvacea*.

None of the victims was a member of the Oregon Mycological Society, a regional organization affiliated with the North American Mycological Association. The mushrooms were found in the Columbia River Gorge, and were eaten in a stir-fry dish Oct. 22.

Four of the five received liver transplants, and as of mid-November all five were doing "as well as could be expected." Because of the liver transplants, the four will be on medication permanently to suppress their immune systems and prevent their new livers from being rejected.

Preston Alexander, president of the Oregon Mycological Society and a member of the society's toxicology committee, identified the *Amanita phalloides*. "They called me in right away," he said. "I think those patients were handled as well as they could have been anywhere." He said poison control centers in this country and toxicologists in this country and overseas were consulted by telephone.

Alexander himself is a biochemist with the Oregon Health Sciences University in Portland, and the event has reinforced his intention to write a book on current approaches to dealing with poisoning from amatoxin-containing mushrooms.

In addition to the liver transplants for four of them, all the victims received a drug derived from the European milk thistle, Alexander said. It had to be administered orally, because its intravenous use is not yet approved in this country.

The Oregon poisonings are either the second or third incidents in this country which led to liver transplants being used to combat death cap poisoning. A year ago in the San Francisco Bay area, a couple consumed *Amanita phalloides* and both survived after liver transplants at the UCLA medical center. There may have been a similar case two years earlier in California, but no details ever have been provided.

Report those incidents

Mushroom poisoning should be reported to the North American Mycological Association to allow that organization to augment and refine its information on the edibility of different species. The "poisoning" need not be severe; even mild gastro-intestinal upsets should be reported.

Dr. Kenneth W. Cochran has turned over the chairmanship of NAMA's toxicology committee to Dr. Kenneth F. Lampe, and reports should be sent to Lampe at Division of Drugs and Toxicology, American Medical Association, 535 N. Dearborn St., Chicago, Ill. 60610 (phone 312-645-4559). Most regional mycological groups have copies of the report form to be used, or they may be obtained from Dr. Lampe.

From the Centers for Disease Control and Prevention

Leads From the Morbidity and Mortality Weekly Report
Atlanta, Ga

Amanita phalloides Mushroom Poisoning— Northern California, January 1997

MMWR. 1997;46:489-492

THE POPULAR interest in gathe

drome requiring intubation and me- diarrhea and weakness

Family poisoned by fungi

Liver transplant set for 13-year-old girl

Associated Press

SAN FRANCISCO – A teenage girl, near death from eating hand-picked "death cap" mushrooms, was to undergo an emergency liver transplant late Wednesday.

Sebastiani Dies From Mushrooms

Member of winemaking family ate 'death caps'

MUS

From Page

tal liver fail

"Even pe
quite well-i
mushrooms
about what
UCSF gastr
than Bass.
who were

Poison mushroom claims man's life

By Russ Parsons
Los Angeles Times

Sam Sebastiani Jr., a member

days, damage to the liver can result in coma and then death.

David Arora, one of the state's

helped along recently by a string of rainy winters. It is commonly found among California live oa

Emerging Amanita





Amanita Phalloides

- Leading Cause of death from mushrooms, worldwide.
- First US case in Chico, Ca in 1871.
- Pacific Northwest, British Columbia, and California have largest number of cases.
- Ectomycorrhizal: symbiotic relationship with root structure of oaks and nut trees.

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IMAGES

Amanita phalloides poisoning

LOREN KEITH FRENCH[1], ROBERT G. HENDRICKSON[2], and B. ZANE HOROWITZ[3]

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[3]*Oregon-Alaska Poison Center, Oregon Health & Science University, Portland 97239, USA*



Amanitin-Containing Amanita species

- *Amanita phalloides*
- *Amanita virosa*
- *Amanita verna*
- *Amanita ocreata*
- *Amanita bisporigera*
- *Amanita suballiacea*
- *Amanita exitalis*

Amanita virosa *Amanita verna*





Group I Mushrooms

Amanita phalloides (Death Cap)

Amanita verna (Destroying Angel)

Amanita virosa (Fool's Mushroom)

Lepiota helveola

Lepiota chlorophyllum

Galerina autumalis

Conocybe filaris

Lepiota



Galerina



Lepiota subincarnata



Galerina autumalis

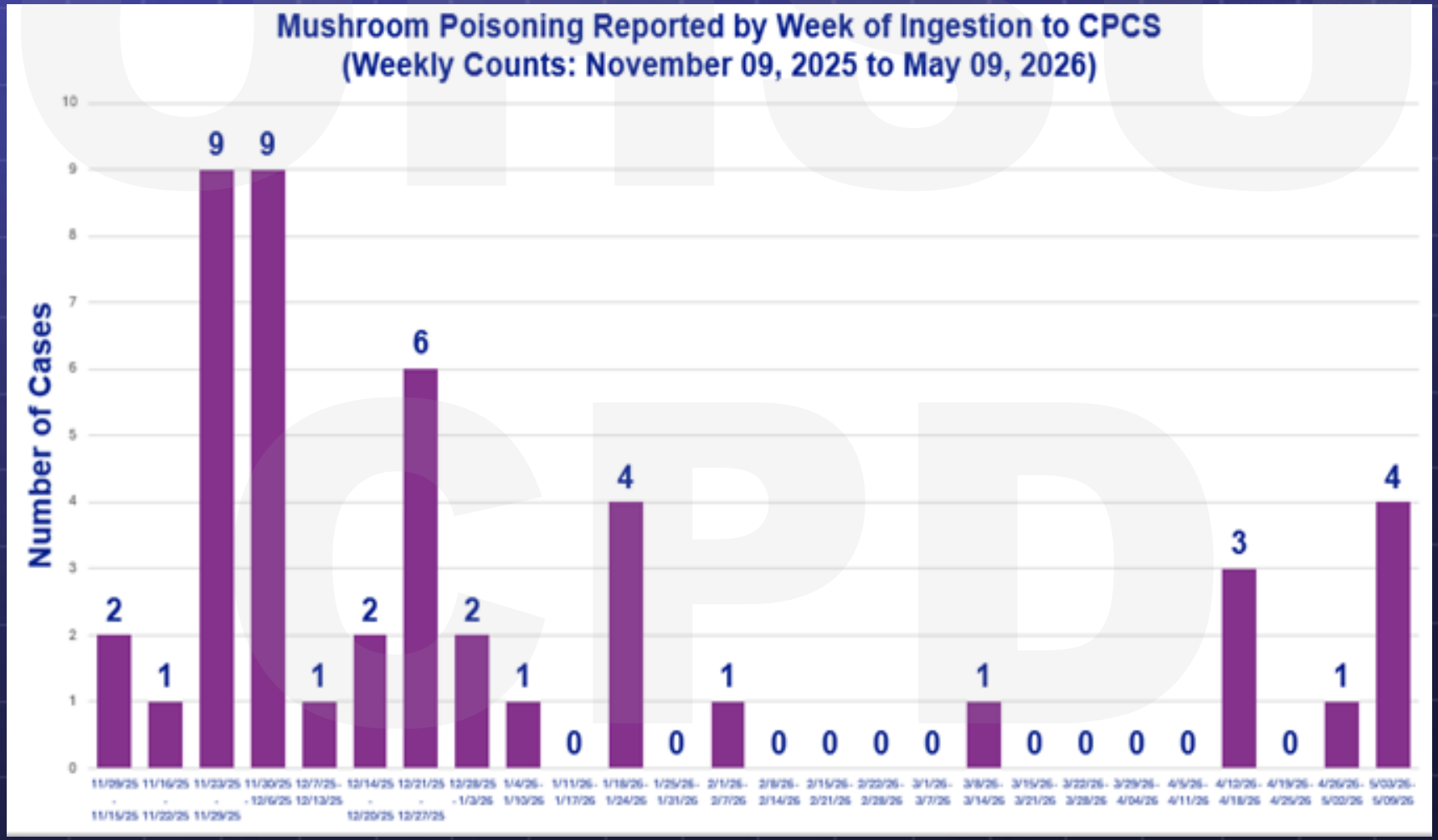


Amanita ocreata
(Western Destroying Ange)
Spring Mushroom



California 2026:

47 cases; 4 liver Tx; 4 deaths



Group I Toxins

Amatoxins

- ***alpha*** **– Amanitin**
- ***beta, gamma, epsilon***

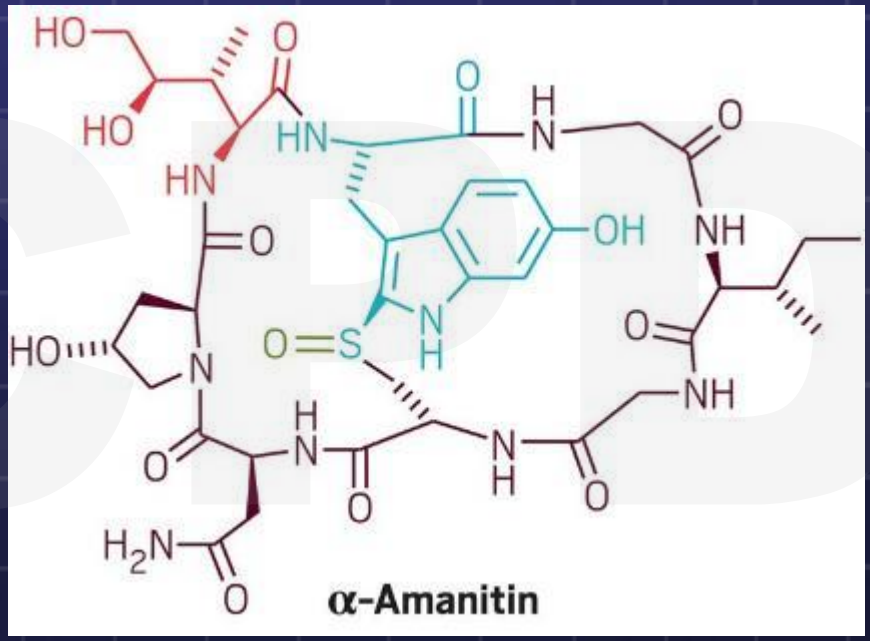
Phallotoxins (low bioavailability)

Bind F-Actin in muscle

- **Phalloidin**
- **Viroisin**

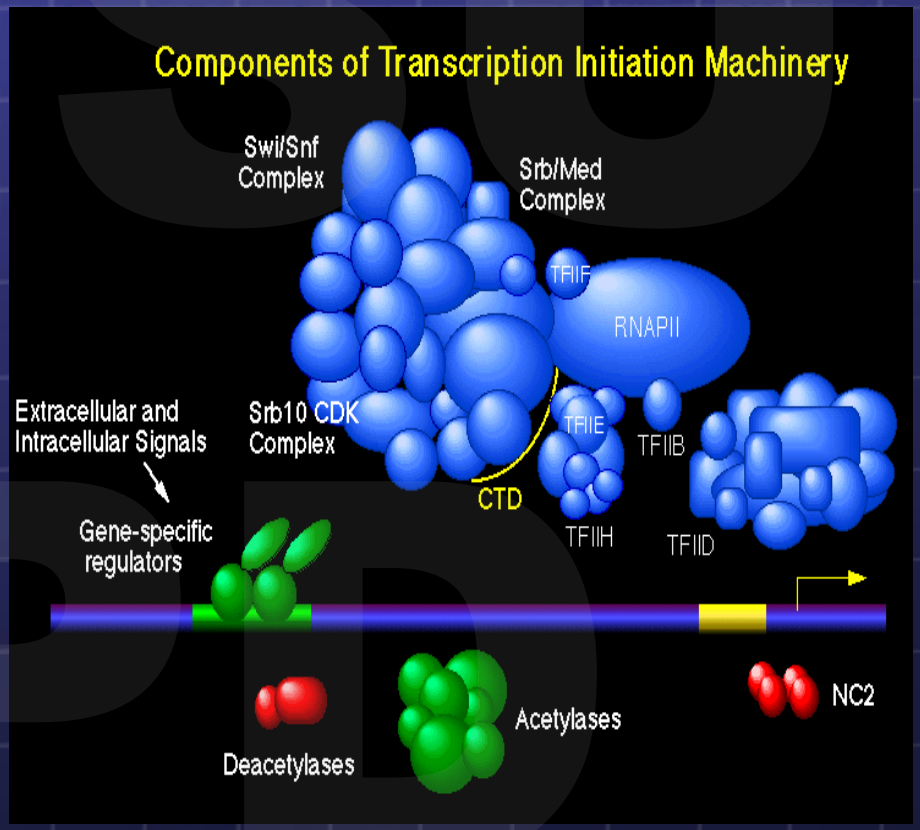
Group I Amatoxins

- Heat Stable
- Cyclopeptides (bicyclic octapetides)
- Hepatotoxic



Pathophysiology of Alpha-Amanitin

- Binds to & Inhibits RNA polymerase II
- Disrupts transcription of mRNA
- Cells cannot make key protein coding genes
- Leads to disintegration of nucleoli
- Centrilobular hepatic necrosis



Amanitin Toxicokinetics

- No protein binding
- Hepatic uptake - but no Metabolism
- Entero-hepatic Recirculation
- Renal excretion 85% first 24 hours

Amanitin Testing

GOLD STANDARD:

GC/MS or LC/MS (generally unavailable)

- also ELISA and RIA assays

New Urine Lateral Flow Assay – detects to 50 ng/ml amanitin

- Point-of-care Urine colorimetric test
- Verified on spiked urine samples
- Verified on dogs who ate Amanitin mushrooms
- NOT verified (yet) in humans

Phases of Toxicity

Phase I	Asymptomatic	0 - 6 hrs (sometimes 12 hrs)
Phase II	Cholera-like	6 - 24 hrs
Phase III	Latent Period	24 - 48 hrs *
Phase IV	Hepatic Necrosis	48 + hrs

* Alpha-amanitin may be detected in plasma 36 to 48 hrs

In Urine up to 4 days

Phase IV Toxicity

Rising Hepatic Transaminases

Elevated Bilirubin

Coagulopathy (INR or prothrombin index)

Hepatorenal Syndrome

Hepatic Encephalopathy

Elevated Lactate

Low phosphorus

Pierre Bastien's Regimen

- Vitamin C
- Vitamin B
- Nifuroxazide
  Oral nitrofuran antibiotic
- Neomycin



Treatment options

Prevent Hepatic Uptake
(Block it on the way in)

- **High dose penicillin (4 mil U Q4H)**

  1,000,000 U/kg x 1 d
  500,000U/kg x 2 d

- **Silibinin (20 to 50 mg/kg/day)**

Enterohepatic recirculation
(Block it on the way out)

- Multi-dose activated charcoal (50 Gm Q2H)
- ? Biliary drainage (ERCP vs surgical)

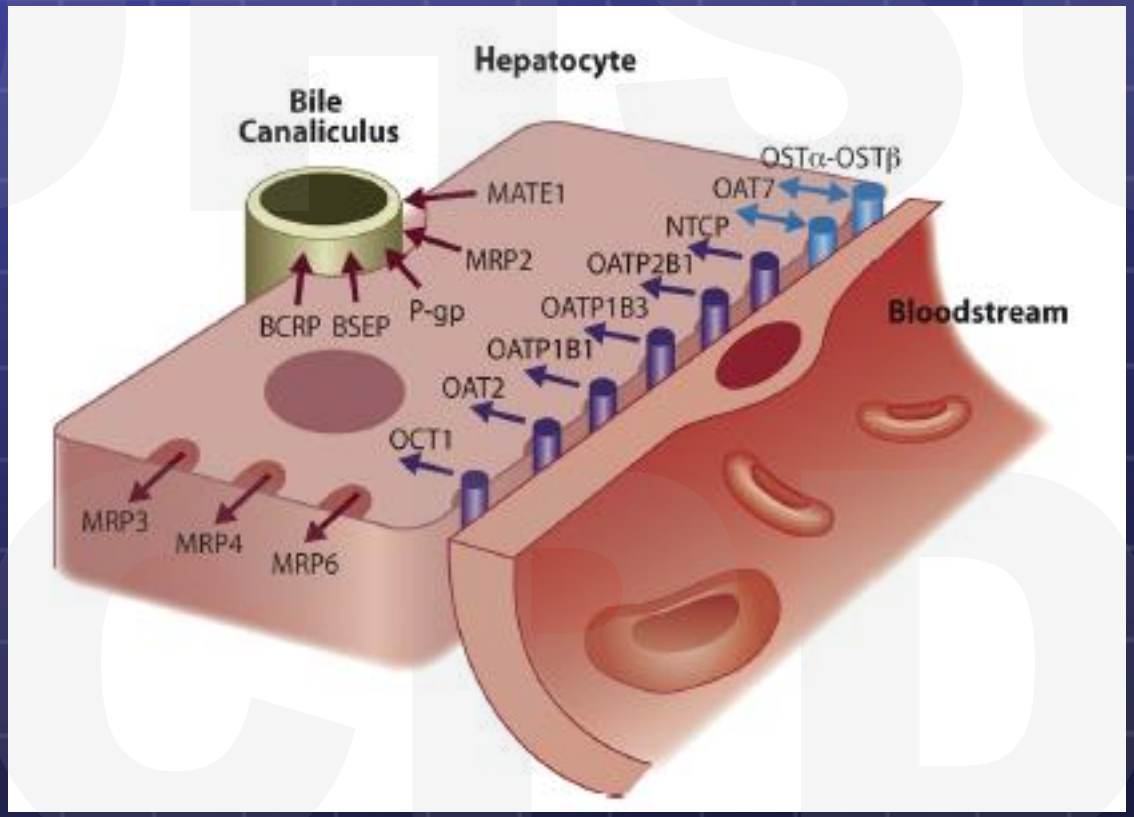
Penicillin equivalent to Silibinin: Retrospective Review

Amanitin intoxication: effects of therapies on clinical outcomes – a review of 40 years of reported cases

Jia Lin Tan[a], Janine Stam[a,b], Aad P. van den Berg[c], Patrick F. van Rheenen[d], Bart G. J. Dekkers[a] and Daan J. Touw[a,e]

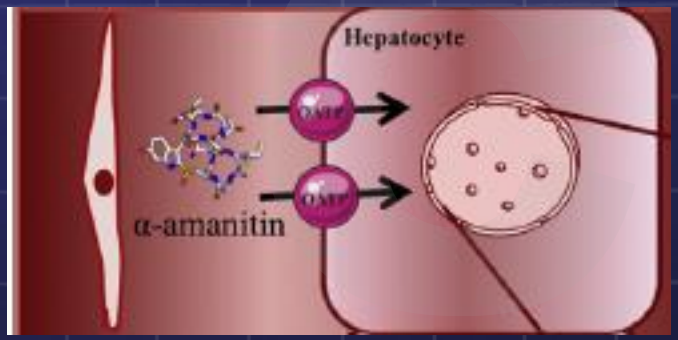
Conclusion: Based on data available, no statistical differences could be observed for the effects of NAC, PEN or SIL in proven poisonings with amanitin-containing mushrooms. However, monotherapy with SIL or PEN and combination therapy with NAC/SIL appear to be associated with higher survival

OAT P Transporters



Interrupting OATP1B3

- Organic acid transporters
  - Multiple subtypes for transporting molecules into the hepatocytes
  - Amanitin is transported by subtype 1B3



- **Possible Inhibiters:**
  - **Penicillin**
  - **Silymarin**
  - **Rifampin**
  - **Cyclosporine**
  - **Paclitaxel**
  - **Cobicistat**

Silymarin

- Derived from Milk Thistle *(Silybum marianum)*
- Contains 4 flavonolignans:
  - Silybinin
  - Isosilybinin
  - Silychristin
  - Silydianin



IV Silibinin

- Silymarin was isolated in 1968 at the University of Munich.
- Patented by the German herbal medicine manufacturer Madaus.
- In 1995, they developed a method to produce 90 to 96% pure silibinin.

LEGALON-SIL is the IV formulation in Germany

- Dose: 20 to 50 mg/kg/day po
  - 5 mg/kg load over 1 hr, then 20mg/kg/day

Milk Thistle Extract



The Oral Bioavailability problem : Solved?

- Oral bioavailability improved by a variety of pharmaceutical manufacturing enhancements.
- However we never know what each individual hospital will get.

Bioavailability: Phosphatidylcholine complex

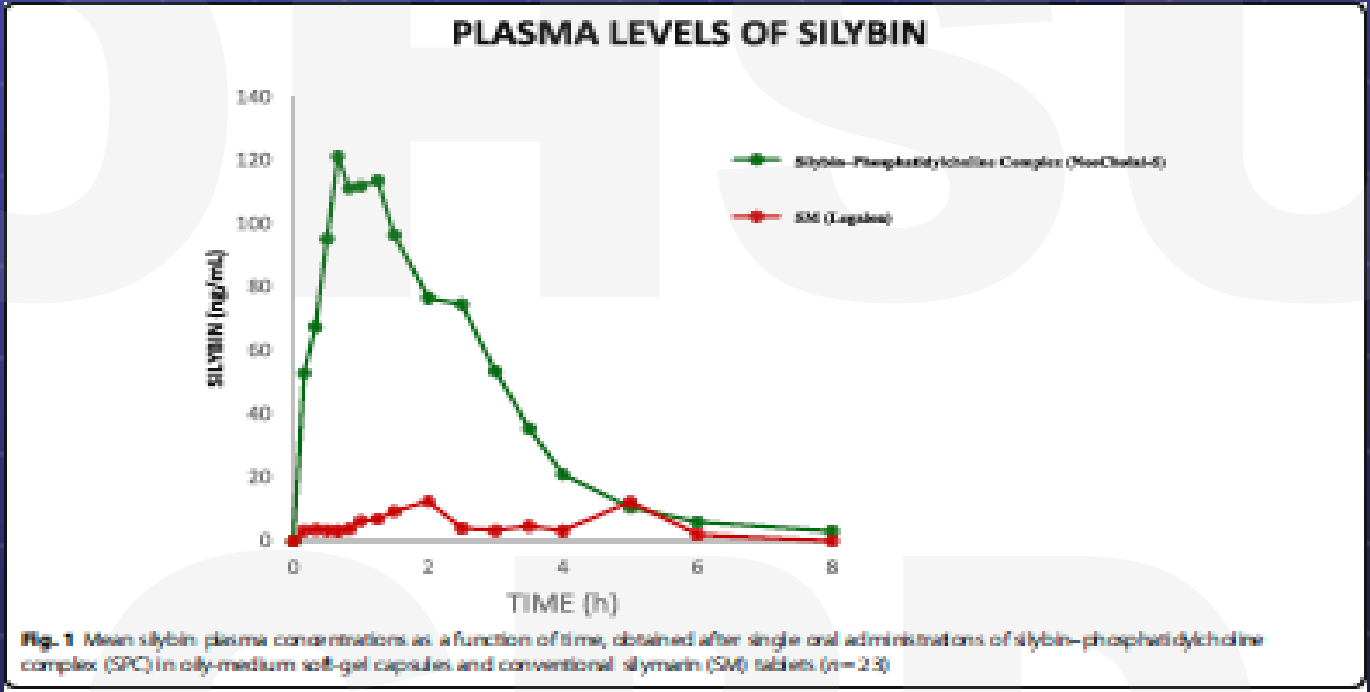


Fig. 1 Mean silybin plasma concentrations as a function of time, obtained after single oral administrations of silybin–phosphatidylcholine complex (SPC) in oily-medium soft-gel capsules and conventional silymarin (SM) tablets ($n = 23$)

Table 1 Mean pharmacokinetic parameters obtained from 23 volunteers after administration of each Silybin formulation

	SPC soft-gel capsule Mean ± SE	SM tablets Mean ± SE
T_{max} (h)	1.1 ± 0.7	1.9 ± 0.9
C_{max} (ng/mL)	207.1 ± 62.4	12.6 ± 31.4
AUC_{0-T} (ng/h/mL)	302.6 ± 126.6	26.4 ± 56.7
$AUC_{0-\infty}$ (ng/h/mL)	308.8 ± 126.1	29.5 ± 14.1
$t_{½}$ (h)	1.4 ± 0.5	4.6 ± 5.8

Research Article

The Bioavailability and Pharmacokinetics of Silymarin SMEDDS Formulation Study in Healthy Thai Volunteers

Self-Microemulsifying Drug Delivery System (SMEDDS)

Pharmacokinetics Parameters	Silybin (mean ± SD)	
	Silymarin SMEDDS soft capsules	Publis Conventional capsule*
t_{max} (h)#	0.80 (0.25-1.67)	1.50 (0.50-8.0)#
C_{max} (/ngml)	812.43 ± 434.07	137.40 ± 51.83
AUC_{0-t} (ng.h/ml)	658.80 ± 266.23	294.80 ± 95.58
AUC_{0-inf} (ng.h/ml)	676.98 ± 268.34	299.10 ± 96.00

Current fatality rate of suspected cyclopeptide mushroom poisoning in the United States

Jonathan De Olano[a], Josh J. Wang[a], Eric Villeneuve[b], Sophie Gosselin[c,d,e], Rana Biary[a], Mark K. Su[a,f] and Robert S. Hoffman[a]

Therapies given (*n*)*	
Biliary drainage	3
H_2 receptor antagonist	9
Multiple dose activated charcoal	35
Single dose activated charcoal	12
N-acetylcysteine	101
Penicillin	42
Renal replacement therapy	12
Silibinin intravenously	30
Silibinin orally	12

All 12 cases that received oral silymarin survived.

Table 2. Case fatality rate.

	Total (*n*)	Died (*n*)	Case Fatality (%)
Overall	148	13	8.8%
Overall treated with silibinin/silymarin	42	4	9.5%
Overall not treated with silibinin/silymarin	106	9	8.5%
Mycologist identified cyclopeptide mushroom treated with silibinin/silymarin	10	1	10%
Mycologist identified cyclopeptide mushroom not treated with Silibinin/silymarin	10	1	10%

COMMENTARY

Silibinin: a toxicologist's herbal medicine?

B. Zane Horowitz

Oregon-Alaska Poison Center, Oregon Health Sciences University, Portland, OR, USA

ABSTRACT

Silymarin is an herbal remedy, commonly called milk thistle, or St. Mary's Thistle, and has been used for over 2000 years. It has been available as a capsule of the plant extract in Europe since 1974 to treat hepatic disorders. To date toxicologists have relied on animal studies, human case series, or retrospective reviews to decide on its use. In the U.S. the ability to use IV silibinin, its pharmacologically active purified flavonolignan, is hindered by its lack of availability as a Food and Drug Administration approved pharmaceutical preparation. This commentary reviews the *in vitro* studies, animal studies, and human retrospective analyses which form the basis for its clinical use. Despite the numerous publications, summarized in this issue in a systematic review, the mortality rate from Amanita mushroom ingestion remains stubbornly the same over four decades of use, and hovers around 10%. Although in the retrospective systematic review the use of silibinin, or penicillin, compared to routine care is statistically significantly superior when the primary outcome is fatality. Despite this there is no quality randomized trial to definitively demonstrate its utility. While, intravenous silibinin has a low toxicity, unanswered is whether it is useful in protecting the liver in cases of amanitin-containing mushrooms toxicity, and whether earlier administration would likely improve outcomes.

Amanita Treatment: IV NAC

IV N-Acetyl cysteine

- Most recent US case reports use it, true efficacy will never be known

CLINICAL TOXICOLOGY
https://doi.org/10.1080/15563650.2020.1784428

Taylor & Francis
Taylor & Francis Group

REVIEW

Check for updates

N-acetylcysteine as a treatment for amatoxin poisoning: a systematic review

Jiaming Liu[a], Yang Chen[b], Yanxia Gao[c], Joseph Harold Walline[d], Xin Lu[a], Shiyuan Yu[a], Lina Zhao[a], Zengzheng Ge[a] and Yi Li[a]

Amanita Phalloides:
Treatments of untested value ???

- Prednisone
- Thiotic acid – risk of hypoglycemia
- Iridoid glycosides (kutkin)

- Charcoal and XAD Hemoperfusion
- Dialysis & CRRT - if hepatorenal syndrome
- Plasmapheresis – grade III encephalopathy
- MARS or Prometheus
  - as bridge to transplant or improvement



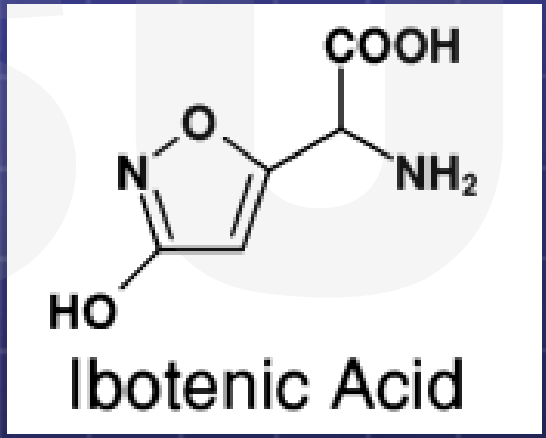


Amanita muscaria

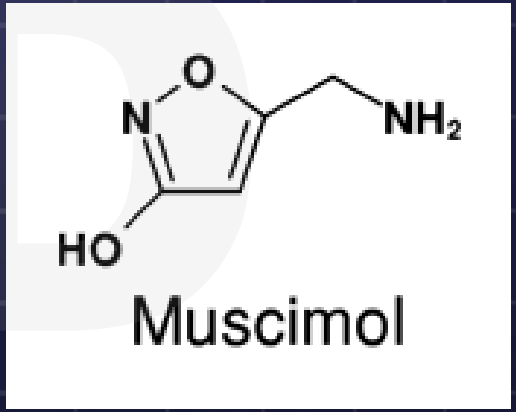


Group V Isoxazoles

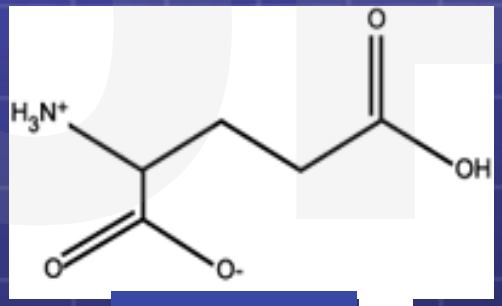
- Ibotenic acid
  - Agonist at NMDA receptor
  - metabolized to Muscimol



- Muscimol
  - Acts at $GABA_A$ receptors

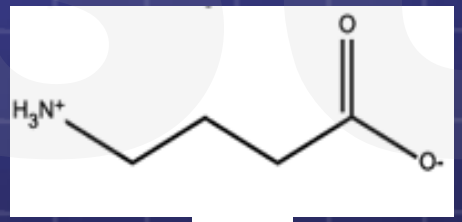


Decarboxylation pathway

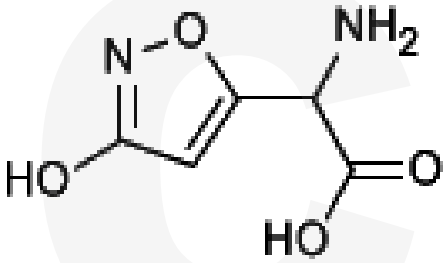


Glutamate

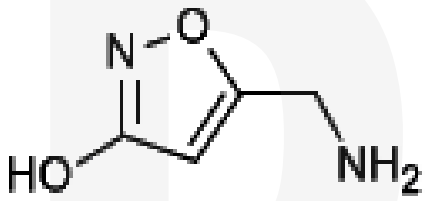
decarboxylation



GABA



Ibotenic acid



Muscimol

Amanita muscaria





Amanita pantherina (the panther mushroom)



Amanita muscaria variant



Oregon Mycologic Society

Species identified in ERs: 1985 - 1997

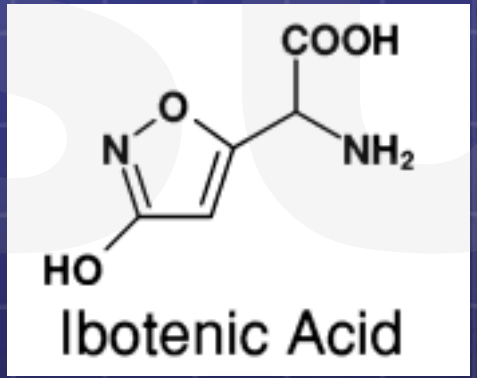
Amanita pantherina	32
Psilocybe	26
Unknowns	22
Morels (Marchella)	17
Amanita muscaria	16
Chanterelles	13
Sulphur mushroom	13
Amanita phalloides	5
Amanita ocreata	3
Amanita smithiana	2

Amanita gemmata

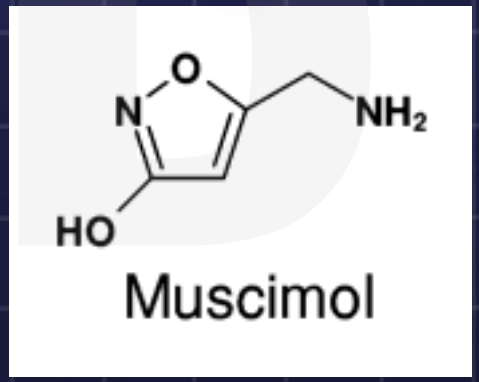


Group V Manifestations

- ? no GI prodrome
- Hallucinations & Delirium, followed by sedation
- Onset 20 to 90 minutes
- Duration up to 8 hours



Ibotenic Acid

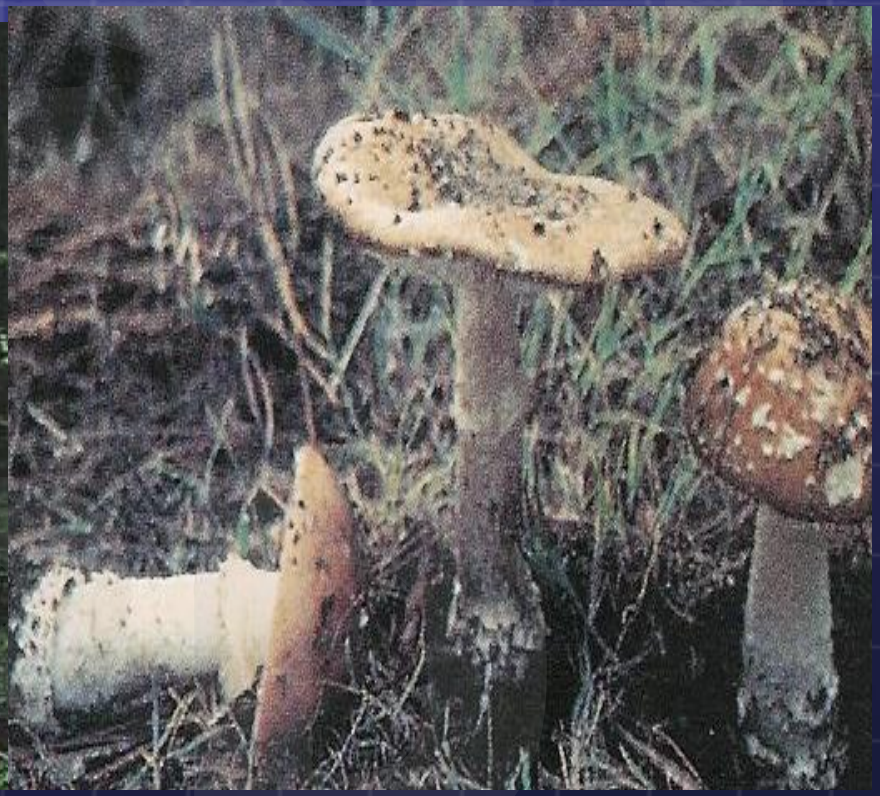


Muscimol

Amanita muscaria



Amanita pantherina



CLINICAL RESEARCH

Check for updates

Toxicity of muscimol and ibotenic acid containing mushrooms reported to a regional poison control center from 2002–2016*

Michael J. Moss[a,b] and Robert G. Hendrickson[a,b]

[a]Department of Emergency Medicine, Oregon Health and Science University, Portland, OR, USA; [b]Oregon Poison Center, Portland, OR, USA

- 15-year retrospective study
- 23 cases of *Amanita muscaria* (1/3 mycologist identified)
  - 11/23 accidental toddler ingestions (all did well)
  - No Seizures; equal amounts CNS excitation and depression
  - 1 patient intubated after benzos for agitation
- 10 cases of *Amanita pantherina* (100% mycologist identified)
  - 9/10 foragers GI symptoms common (8/10)
  - 3 patients intubated / 5 ICU admissions / No Seizures

Amanita muscaria and *Amanita pantherina* poisoning: Two syndromes

Andreja Vendramin, Miran Brvar*

Poison Control Centre, Division of Internal Medicine, University Medical Centre Ljubljana, Zaloška cesta 7, Slovenia

TOXICON: Slovenian Poison Center case series 6 each with coma or seizures

Symptoms and signs after *A. muscaria* and *A. pantherina* ingestion in 49 patients treated in the Ljubljana Poison Control Centre in the past 33 years.

	Amanita muscaria ($n = 32$)	*Amanita pantherina* ($n = 17$)	p value
Confusion	26	8	0.01
Agitation	20	5	0.03
Hallucinations	10	7	0.49
Myoclonus	6	6	0.20
Convulsions	4	2	0.94
Somnolence	13	5	0.44
Coma	2	5	0.03
Vomiting	18	11	0.57
Diarrhoea	5	4	0.50

Treatment:

Isoxazole Mushroom Toxicity

Usually self limited

Accidental toddler ingestions can be watched at home with call back for symptoms

Benzodiazepines (sparingly) for excitatory (NMDA) phase, but will be additive with Muscimol at GABA

Fly agaric


Fly agaric - used
by European housewives
to kill flies -
Amanita muscaria

Berserkers?



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journal homepage: www.elsevier.com/locate/jethpharm

Sagas of the Solanaceae: Speculative ethnobotanical perspectives on the Norse berserkers

Karsten Fatur

University of Ljubljana, Faculty of Pharmacy, 32 Tržaška Cesta, 1000, Ljubljana, Slovenia

The Saga continues: Solanaceae May cast too much shade for effective berserking

Adam Blumenberg*

Department of Emergency Medicine and Toxicology, Oregon Poison Center, Oregon Health and Science University, Portland, OR, USA

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Zane Horowitz

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Gelukkig Nieuwjaar




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AMANITA PHALLOIDES





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