WIKIPEDIA

Acetylcysteine

Acetylcysteine, also known as ***N*-acetylcysteine** (**NAC**), is a medication that is used to treat paracetamol overdose and to loosen thick mucus in individuals with chronic bronchopulmonary disorders like pneumonia and bronchitis.[2] It has been used to treat lactobezoar in infants. It can be taken intravenously, by mouth, or inhaled as a mist.[2] Some people use it as a dietary supplement.[6][7]

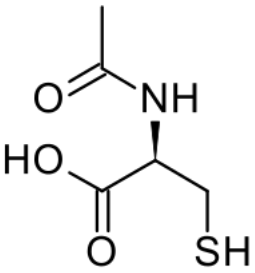
Common side effects include nausea and vomiting when taken by mouth.[2] The skin may occasionally become red and itchy with any route of administration.[2] A non-immune type of anaphylaxis may also occur.[2] It appears to be safe in pregnancy.[2] For paracetamol overdose, it works by increasing the level of glutathione, an antioxidant that can neutralise the toxic breakdown products of paracetamol.[2] When inhaled, it acts as a mucolytic by decreasing the thickness of mucus.[8]

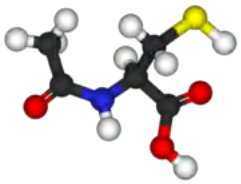
Acetylcysteine was initially patented in 1960 and came into medical use in 1968.[9][10][11] It is on the World Health Organization's List of Essential Medicines.[12] It is available as a generic medication and is inexpensive.[13]

The sulfur-containing amino acids cysteine and methionine are more easily oxidized than the other amino acids.[14][15]

Contents

Acetylcysteine





Clinical data	
Pronunciation	/əˌsiːtəlˈsɪstiːn/ and similar (/əˌsɛtəl-, ˌæsɪtəl-, -tiːn/)
Trade names	Acetadote, Fluimucil, Mucomyst, others
Other names	*N*-acetylcysteine; *N*-acetyl-L-cysteine; NALC; NAC
AHFS/Drugs.com	Monograph (https://www.drugs.com/monograph/acetylcysteine.html)
License data	US DailyMed: Acetylcysteine (https://dailymed.nlm.nih.gov/dailymed/search.cfm?labeltype=all&query=Acetylcysteine) US FDA: Acetylcysteine (https://www.accessdata.fda.gov/scripts/cder/drugsatfda/index.cfm?fuseaction=Search.SearchAction&SearchTerm=Acetylcysteine&SearchType=BasicSearch)
Pregnancy category	AU: B2
Routes of administration	By mouth, injection,

Uses

Paracetamol overdose

Intravenous and oral formulations of acetylcysteine are available for the treatment of paracetamol (acetaminophen) overdose.[16] When paracetamol is taken in large quantities, a minor metabolite called *N*-acetyl-*p*-benzoquinone imine (NAPQI) accumulates within the body. It is normally conjugated by glutathione, but when taken in excess, the body's glutathione reserves are not sufficient to deactivate the toxic NAPQI. This metabolite is then free to react with key hepatic enzymes, thereby damaging liver cells. This may lead to severe liver damage and even death by acute liver failure.

In the treatment of paracetamol (acetaminophen) overdose, acetylcysteine acts to maintain or replenish depleted glutathione reserves in the liver and enhance non-toxic metabolism of acetaminophen.[17] These actions serve to protect liver cells from NAPQI toxicity. It is most effective in preventing or lessening hepatic injury when administered within 8–10 hours after overdose.[17] Research suggests that the rate of liver toxicity is approximately 3% when acetylcysteine is administered within 10 hours of overdose.[16]

Although IV and oral acetylcysteine are equally effective for this indication, oral administration is generally poorly tolerated due to the higher dosing required to overcome its low oral bioavailability,[18] its foul taste and odour, and a higher incidence of adverse

	inhalation
ATC code	R05CB01 (WHO (https://www.whocc.no/atc_ddd_index/?code=R05CB01)) S01XA08 (WHO (https://www.whocc.no/atc_ddd_index/?code=S01XA08)) V03AB23 (WHO (https://www.whocc.no/atc_ddd_index/?code=V03AB23))
Legal status	
Legal status	AU: S2 (Pharmacy medicine) BR: OTC (Over the counter) (by mouth, IV, inhalation) US: OTC (by mouth), Rx-only (IV, inhalation)
Pharmacokinetic data	
Bioavailability	10% (Oral)[1]
Protein binding	50 to 83%[2]
Metabolism	Liver[2]
Elimination half-life	5.6 hours[3]
Excretion	Renal (30%),[2] faecal (3%)
Identifiers	
IUPAC name	(2*R*)-2-acetamido-3-sulfanylpropanoic acid[4]
CAS Number	616-91-1 (https://commonchemistry.cas.org/detail?cas_rn=616-91-1) ✓
PubChem CID	12035 (https://pubchem.ncbi.nlm.nih.gov/compound/12035)
DrugBank	DB06151 (https://www.drugbank.ca/drugs/DB06151) ✓
ChemSpider	11540 (https://www.chemspider.com/Chemical-Structure.11540.html) ✓
UNII	WYQ7N0BPYC (https://precision.fda.gov/uniisearch/srs/unii/WYQ7N0BPYC)

effects when taken by mouth, particularly nausea and vomiting. Prior pharmacokinetic studies of acetylcysteine did not consider acetylation as a reason for the low bioavailability of acetylcysteine.[19] Oral acetylcysteine is identical in bioavailability to cysteine precursors.[19] However, 3% to 6% of people given intravenous acetylcysteine show a severe, anaphylaxis-like allergic reaction, which may include extreme breathing difficulty (due to bronchospasm), a decrease in blood pressure, rash, angioedema, and sometimes also nausea and vomiting.[20] Repeated doses of intravenous acetylcysteine will cause these allergic reactions to progressively worsen in these people.

Several studies have found this anaphylaxis-like reaction to occur more often in people given intravenous acetylcysteine despite serum levels of paracetamol not high enough to be considered toxic.[21][22][23][24]

Lungs

Inhaled acetylcysteine has been used for mucolytic ("mucus-dissolving") therapy in addition to other therapies in respiratory conditions with excessive and/or thick mucus production. It is also used post-operatively, as a diagnostic aid, and in tracheotomy care. It may be considered ineffective in cystic fibrosis.[25] A 2013 Cochrane review in cystic fibrosis found no evidence of benefit.[26]

Acetylcysteine is used in the treatment of obstructive lung disease as an adjuvant treatment.[27][28][29]

Kidney and bladder

Evidence for the benefit of acetylcysteine to prevent radiocontrast induced kidney disease is mixed.[30]

Acetylcysteine has been used for cyclophosphamide-induced haemorrhagic cystitis, although mesna is generally preferred due to the ability of acetylcysteine to diminish the effectiveness of cyclophosphamide.[31]

KEGG	D00221 (https://www.kegg.jp/entry/D00221) ✓
ChEBI	CHEBI:28939 (https://www.ebi.ac.uk/chebi/searchId.do?chebiId=CHEBI:28939) ✓
ChEMBL	ChEMBL600 (https://www.ebi.ac.uk/chembldb/index.php/compound/inspect/ChEMBL600) ✓
CompTox Dashboard (EPA)	DTXSID5020021 (https://comptox.epa.gov/dashboard/chemical/details/DTXSID5020021)
ECHA InfoCard	100.009.545 (https://echa.europa.eu/substance-information/-/substanceinfo/100.009.545)
Chemical and physical data	
Formula	$C_5H_9NO_3S$
Molar mass	163.19 g·mol^{-1}
3D model (JSmol)	Interactive image (https://chemapps.stolaf.edu/jmol/jmol.php?model=C%2FC%28%3DN%2F%5BC%40%40H%5D%28CS%29C%28%3DO%29O%29%2FO)
Specific rotation	+5° (c = 3% in water)[5]
Melting point	109 to 110 °C (228 to 230 °F) [5]
SMILES	C/C(=N/[C@@H](CS)C(=O)O)/O
InChI	InChI=1S/C5H9NO3S/c1-3(7)6-4(2-10)5(8)9/h4,10H,2H2,1H3,(H,6,7)(H,8,9)/t4-/m0/s1 ✓ Key:PWKSKIMOESPYIA-BYPYZUCNSA-N ✓
(verify)	

Psychiatry

Acetylcysteine has been studied for major psychiatric disorders,[32][33][34][35] including bipolar disorder,[32] major depressive disorder, and schizophrenia.[33][34]

Tentative evidence exists for *N*-acetylcysteine also in the treatment of Alzheimer's disease, autism, obsessive-compulsive disorder, specific drug addictions (cocaine), drug-induced neuropathy, trichotillomania, excoriation disorder, and a certain form of epilepsy (progressive myoclonic).[33][34][36] Preliminary evidence showed efficacy in anxiety disorder, attention deficit hyperactivity disorder and mild traumatic brain injury although confirmatory studies are required.[36][37][38][39] Tentative evidence also supports use in cannabis use disorder.[40]

Bipolar disorder

In bipolar disorder, *N*-acetylcysteine has been repurposed as an augmentation strategy for depressive episodes in light of the possible role of inflammation in the pathogenesis of mood disorders. Nonetheless, meta-analytic evidence shows that add-on *N*-acetylcysteine was more effective than placebo only in reducing depression scales scores (low quality evidence), without positive effects on response and remission outcomes, limiting its possible role in clinical practice to date.[32]

Addiction

Evidence to date does not support the efficacy for *N*-acetylcysteine in treating addictions to gambling, methamphetamine, or nicotine.[36] Based upon limited evidence, NAC appears to normalize glutamate neurotransmission in the nucleus accumbens and other brain structures, in part by upregulating the expression of excitatory amino acid transporter 2 (EAAT2), a.k.a. glutamate transporter 1 (GLT1), in individuals with addiction.[41] While NAC has been demonstrated to modulate glutamate neurotransmission in adult humans who are addicted to cocaine, NAC does not appear to modulate glutamate neurotransmission in healthy adult humans.[41] NAC has been hypothesized to exert beneficial effects through its modulation of glutamate and dopamine neurotransmission as well as its antioxidant properties.[34]

Microbiological use

Acetylcysteine can be used in Petroff's method of liquefaction and decontamination of sputum, in preparation for recovery of mycobacterium.[42] It also displays significant antiviral activity against the influenza A viruses.[43]

Acetylcysteine has bactericidal properties and breaks down bacterial biofilms of clinically relevant pathogens including *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Enterococcus faecalis*, *Enterobacter cloacae*, *Staphylococcus epidermidis*, and *Klebsiella pneumoniae*.[44]

Other uses

Acetylcysteine has been used to complex palladium, to help it dissolve in water. This helps to remove palladium from drugs or precursors synthesized by palladium-catalyzed coupling reactions.[45] *N*-actelylcysteine can be used to protect the liver.[46]

Side effects

The most commonly reported adverse effects for IV formulations of acetylcysteine are rash, urticaria, and itchiness.[17] Up to 18% of patients have been reported to experience anaphylaxis reaction, which are defined as rash, hypotension, wheezing, and/or shortness of breath. Lower rates of anaphylactoid reactions have been reported with slower rates of infusion.

Adverse effects for inhalational formulations of acetylcysteine include nausea, vomiting, stomatitis, fever, rhinorrhea, drowsiness, clamminess, chest tightness, and bronchoconstriction. Although infrequent, bronchospasm has been reported to occur unpredictably in some patients.[47]

Adverse effects for oral formulations of acetylcysteine have been reported to include nausea, vomiting, rash, and fever.[47]

Large doses in a mouse model showed that acetylcysteine could potentially cause damage to the heart and lungs.[48] They found that acetylcysteine was metabolized to *S*-nitroso-*N*-acetylcysteine (SNOAC), which increased blood pressure in the lungs and right ventricle of the heart (pulmonary artery hypertension) in mice treated with acetylcysteine. The effect was similar to that observed following a 3-week exposure to an oxygen-deprived environment (chronic hypoxia). The authors also found that SNOAC induced a hypoxia-like response in the expression of several important genes both *in vitro* and *in vivo*.

The implications of these findings for long-term treatment with acetylcysteine have not yet been investigated. The dose used by Palmer and colleagues was dramatically higher than that used in humans, the equivalent of about 20 grams per day.[48] Nonetheless, positive effects on age-diminished control of respiration (the hypoxic ventilatory response) have been observed previously in human subjects at more moderate doses.[49]

Although *N*-acetylcysteine prevented liver damage in mice when taken before alcohol, when taken four hours after alcohol it made liver damage worse in a dose-dependent fashion.[50]

Pharmacology

Pharmacodynamics

Acetylcysteine serves as a prodrug to L-cysteine, a precursor to the biologic antioxidant glutathione. Hence administration of acetylcysteine replenishes glutathione stores.[51]

- Glutathione, along with oxidized glutathione (GSSG) and *S*-nitrosoglutathione (GSNO), have been found to bind to the glutamate recognition site of the NMDA and AMPA receptors (via their γ-glutamyl moieties), and may be endogenous neuromodulators.[52][53] At millimolar concentrations, they may also modulate the redox state of the NMDA receptor complex.[53] In addition, glutathione has been found to bind to and activate ionotropic receptors that are different from any other excitatory amino acid receptor, and which may constitute *glutathione receptors*, potentially making it a neurotransmitter.[54] As such, since *N*-acetylcysteine is a prodrug of glutathione, it may modulate all of the aforementioned receptors as well.
- Glutathione also modulates the NMDA receptor by acting at the redox site.[34][55]

L-cysteine also serves as a precursor to cystine, which in turn serves as a substrate for the cystine-glutamate antiporter on astrocytes; hence there is increasing glutamate release into the extracellular space. This glutamate in turn acts on $mGluR_{2/3}$ receptors, and at higher doses of acetylcysteine,

$mGluR_5$.[56][57]

Acetylcysteine also possesses some anti-inflammatory effects possibly via inhibiting NF-κB and modulating cytokine synthesis.[34]

Pharmacokinetics

Acetylcysteine is extensively liver metabolized, CYP450 minimal, urine excretion is 22–30% with a half-life of 5.6 hours in adults and 11 hours in newborns.

Chemistry

Acetylcysteine is the *N*-acetyl derivative of the amino acid L-cysteine, and is a precursor in the formation of the antioxidant glutathione in the body. The thiol (sulfhydryl) group confers antioxidant effects and is able to reduce free radicals.

N-acetyl-L-cysteine is soluble in water and alcohol, and practically insoluble in chloroform and ether.[58]

It is a white to white with light yellow cast powder, and has a pK_a of 9.5 at 30 °C.[5]

Dosage forms

Acetylcysteine is available in different dosage forms for different indications:

- Solution for inhalation (Assist, Mucomyst, Mucosil) – inhaled for mucolytic therapy
- Intravenous injection (Assist, Parvolex, Acetadote) – treatment of paracetamol/acetaminophen overdose
- Nebulized as an inhaled vapor, particularly in the treatment of cystic fibrosis and other acute pulmonary conditions
- Oral solution – various indications
- Effervescent tablets
- Ocular solution – for mucolytic therapy
- Tablets – sometimes in a sustained release formula sold as a nutritional supplement
- Capsules

The IV injection and inhalation preparations are, in general, prescription only, whereas the oral solution and the effervescent tablets are available over the counter in many countries. Acetylcysteine is available as a health supplement in the United States, typically in capsule form.

Society and culture

NAC was first studied as a drug in 1963. Amazon removed NAC for sale in the US in 2021, due to claims by the FDA of it being classified as a drug rather than a supplement.[59][60][61][62] As of 21 April 2022, the FDA released draft guidance on FDA's policy regarding products labeled as dietary supplements that contain *N*-acetyl-L-cysteine.[63]

NAC was studied as a drug and is today used as a medicine. It has also been sold as a dietary supplement within the United States prior to the advent of the Dietary Supplement Health Education Act (DSHEA 1994). The American Herbal Products Association (AHPA) and others have provided the FDA with details regarding NAC products sold before 15 October 1994. Additionally, NAC itself is found in a variety of foods (garlic, onions, asparagus, and others).

In 2020 FDA sent warning letters to several companies regarding the use of NAC in dietary supplements. In those letters FDA noted that NAC could not be marketed as a dietary supplement because NAC had NOT been marketed as a food or dietary supplement prior to its approval as a drug. FDA had confirmed in response to two citizen petitions (CRN and NPA) that NAC is excluded from the definition of a dietary supplement. FDA had not yet reached a decision, however, regarding a petitioner's (NPA) request to issue a regulation that would permit the use of NAC in dietary supplements. On April 21, 2022, the FDA announced the availability of a draft guidance on FDA's policy regarding products labeled as dietary supplements that contain *N*-acetyl-L-cysteine. The draft guidance, when finalized, will explain the agency's intent to exercise enforcement discretion with respect to the sale and distribution of certain NAC-containing products that are labeled as dietary supplements. The FDA has asked for comments on its NAC Guidance and has stated that they will use enforcement discretion with respect to NAC supplements.

Research

While many antioxidants have been researched to treat a large number of diseases by reducing the negative effect of oxidative stress, acetylcysteine is one of the few that has yielded promising results, and is currently already approved for the treatment of paracetamol overdose.[64]

- In mouse mdx models of Duchenne's muscular dystrophy, treatment with 1–2% acetylcysteine in drinking water significantly reduces muscle damage and improves strength.[64]
- It is being studied in conditions such as autism, where cysteine and related sulfur amino acids may be depleted due to multifactorial dysfunction of methylation pathways involved in methionine catabolism.[65]
- Animal studies have also demonstrated its efficacy in reducing the damage associated with moderate traumatic brain or spinal injury, and also ischaemia-induced brain injury. In particular, it has been demonstrated to reduce neuronal losses and to improve cognitive and neurological outcomes associated with these traumatic events.[35]
- It has been suggested that acetylcysteine may help people with Samter's triad by increasing levels of glutathione allowing faster breakdown of salicylates, although there is no evidence that it is of benefit.[66]
- Small studies have shown acetylcysteine to be of benefit to people with blepharitis.[67] It has been shown to reduce ocular soreness caused by Sjögren's syndrome.[68]
- It has been shown that *N*-acetylcysteine may protect the human cochlea from subclinical hearing loss caused by loud noises such as impulse noise.[69] In animal models, it reduced age-related hearing loss.
- It has been shown effective in the treatment of Unverricht-Lundborg disease in an open trial in four patients. A marked decrease in myoclonus and some normalization of somatosensory evoked potentials with acetylcysteine treatment has been documented.[70][71]
- Addiction to certain addictive drugs (including cocaine, heroin, alcohol, and nicotine) is correlated with a persistent reduction in the expression of excitatory amino acid transporter 2 (EAAT2) in the nucleus accumbens (NAcc);[41] the reduced expression of EAAT2 in this region is implicated in addictive drug-seeking behavior.[41] In particular, the long-term dysregulation of glutamate

neurotransmission in the NAcc of addicts is associated with an increase in vulnerability to relapse after re-exposure to the addictive drug or its associated drug cues.[41] Drugs that help to normalize the expression of EAAT2 in this region, such as *N*-acetylcysteine, have been proposed as an adjunct therapy for the treatment of addiction to cocaine, nicotine, alcohol, and other drugs.[41]

- It is being tested for the reduction of hangover symptoms, but the clinical trial results are still being evaluated.[72]
- A double-blind placebo controlled trial of 262 patients has shown NAC treatment was well-tolerated and resulted in a significant decrease in the frequency of influenza-like episodes, severity, and length of time confined to bed.[73]

COVID-19

NAC is being considered as a possible treatment for COVID-19.[74][75][76]

References

1. Stockley RA (2008). *Chronic Obstructive Pulmonary Disease a Practical Guide to Management* (https://books.google.com/books?id=y9li1geShyYC&pg=PA750). Chichester: John Wiley & Sons. p. 750. ISBN 9780470755280. Archived (https://web.archive.org/web/20170908143219/https://books.google.com/books?id=y9li1geShyYC&pg=PA750) from the original on 8 September 2017.
2. "Acetylcysteine" (https://www.drugs.com/monograph/acetylcysteine.html). The American Society of Health-System Pharmacists. Archived (https://web.archive.org/web/20150923231013/http://www.drugs.com/monograph/acetylcysteine.html) from the original on 23 September 2015. Retrieved 22 August 2015.
3. "Acetadote (acetylcysteine) injection, solution [Cumberland Pharmaceuticals Inc.]" (http://dailymed.nlm.nih.gov/dailymed/lookup.cfm?setid=472f158a-5ab9-4308-8e49-1116e6ea3d39). *DailyMed*. Cumberland Pharmaceuticals Inc. June 2013. Archived (https://web.archive.org/web/20140113001430/http://dailymed.nlm.nih.gov/dailymed/lookup.cfm?setid=472f158a-5ab9-4308-8e49-1116e6ea3d39) from the original on 13 January 2014. Retrieved 8 November 2013.
4. "L-Cysteine, *N*-acetyl- — Compound Summary" (https://pubchem.ncbi.nlm.nih.gov/summary/summary.cgi?cid=581). *PubChem*. National Center for Biotechnology Information. 25 March 2005. Identification. Archived (https://web.archive.org/web/20140112235508/http://pubchem.ncbi.nlm.nih.gov/summary/summary.cgi?cid=581) from the original on 12 January 2014. Retrieved 9 January 2012.
5. "*N*-Acetyl-L-cysteine Product Information" (https://web.archive.org/web/20140611120709/http://www.sigmaaldrich.com/content/dam/sigma-aldrich/docs/Sigma-Aldrich/Product_Information_Sheet/a7250pis.pdf) (PDF). *Sigma*. Sigma-Aldrich. Archived from the original (https://www.sigmaaldrich.com/content/dam/sigma-aldrich/docs/Sigma-Aldrich/Product_Information_Sheet/a7250pis.pdf) (PDF) on 11 June 2014. Retrieved 9 November 2014.
6. Talbott SM (2012). *A Guide to Understanding Dietary Supplements* (https://books.google.com/books?id=9ZZrW_j9XrcC&pg=PA469). Routledge. p. 469. ISBN 9781136805707. Archived (https://web.archive.org/web/20170908143219/https://books.google.com/books?id=9ZZrW_j9XrcC&pg=PA469) from the original on 8 September 2017.
7. "Cysteine" (http://www.umm.edu/health/medical/altmed/supplement/cysteine). *University of Maryland Medical Center*. Archived (https://web.archive.org/web/20170701184417/http://www.umm.edu/health/medical/altmed/supplement/cysteine) from the original on 1 July 2017. Retrieved 23 June 2017.

8. Sadowska AM, Verbraecken J, Darquennes K, De Backer WA (December 2006). "Role of *N*-acetylcysteine in the management of COPD" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2707813). *International Journal of Chronic Obstructive Pulmonary Disease*. **1** (4): 425–434. doi:10.2147/copd.2006.1.4.425 (https://doi.org/10.2147%2Fcopd.2006.1.4.425). ISSN 1176-9106 (https://www.worldcat.org/issn/1176-9106). PMC 2707813 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2707813). PMID 18044098 (https://pubmed.ncbi.nlm.nih.gov/18044098).
9. Fischer J, Ganellin CR (2006). *Analogue-Based Drug Discovery* (https://books.google.com/books?id=FjKfqkaKkAAC&pg=PA544). Weinheim: Wiley-VCH. p. 544. ISBN 9783527607495. Archived (https://web.archive.org/web/20170908143219/https://books.google.com/books?id=FjKfqkaKkAAC&pg=PA544) from the original on 8 September 2017.
10. US3091569A (https://patents.google.com/patent/US3091569A/en), Leonard, Sheffner Aaron, "Mucolytic-nu-acylated sulfhydryl compositions and process for treating animal mucus", issued 28 May 1963
11. US patent 3091569 (https://worldwide.espacenet.com/publicationDetails/biblio?II=2&ND=3&adjacent=true&locale=en_EP&FT=D&date=19630528&CC=US&NR=3091569A&KC=A), Aaron Leonard Sheffner, "Mucolytic-*N*-acylated sulfhydryl compositions and process for treating animal mucus", published 28 May 1963, issued 28 May 1963, assigned to Mead Johnson & Co
12. *World Health Organization Model List of Essential Medicines: 21st list 2019*. Geneva: World Health Organization. 2019. hdl:10665/325771 (https://hdl.handle.net/10665%2F325771). WHO/MVP/EMP/IAU/2019.06. License: CC BY-NC-SA 3.0 IGO.
13. Baker E (2014). "Acetylcysteine". *Top 100 Drugs: Clinical pharmacology and practical prescribing* (https://books.google.com/books?id=oeYjAwAAQBAJ&pg=PT44). ISBN 9780702055157. Archived (https://web.archive.org/web/20170908143223/https://books.google.com/books?id=oeYjAwAAQBAJ&pg=PT44) from the original on 8 September 2017.
14. Bin P, Huang R, Zhou X (2017). "Oxidation Resistance of the Sulfur Amino Acids: Methionine and Cysteine" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5763110). *BioMed Research International*. **2017**: 9584932. doi:10.1155/2017/9584932 (https://doi.org/10.1155%2F2017%2F9584932). PMC 5763110 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5763110). PMID 29445748 (https://pubmed.ncbi.nlm.nih.gov/29445748).
15. Lee BC, Dikiy A, Kim HY, Gladyshev VN (2009). "Functions and evolution of selenoprotein methionine sulfoxide reductases" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3062201). *Biochimica et Biophysica Acta (BBA) – General Subjects*. **1790** (11): 1471–1477. doi:10.1016/j.bbagen.2009.04.014 (https://doi.org/10.1016%2Fj.bbagen.2009.04.014). PMC 3062201 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3062201). PMID 19406207 (https://pubmed.ncbi.nlm.nih.gov/19406207).
16. Green JL, Heard KJ, Reynolds KM, Albert D (May 2013). "Oral and Intravenous Acetylcysteine for Treatment of Acetaminophen Toxicity: A Systematic Review and Meta-analysis" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3656701). *The Western Journal of Emergency Medicine*. **14** (3): 218–226. doi:10.5811/westjem.2012.4.6885 (https://doi.org/10.5811%2Fwestjem.2012.4.6885). PMC 3656701 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3656701). PMID 23687539 (https://pubmed.ncbi.nlm.nih.gov/23687539).
17. "Acetadote Package Insert" (http://www.accessdata.fda.gov/drugsatfda_docs/label/2006/021539s004lbl.pdf) (PDF). FDA. Archived (https://web.archive.org/web/20130825114200/http://www.accessdata.fda.gov/drugsatfda_docs/label/2006/021539s004lbl.pdf) (PDF) from the original on 25 August 2013. Retrieved 19 April 2014.
18. Borgström L, Kågedal B, Paulsen O (1986). "Pharmacokinetics of *N*-acetylcysteine in man". *European Journal of Clinical Pharmacology*. **31** (2): 217–222. doi:10.1007/bf00606662 (https://doi.org/10.1007%2Fbf00606662). PMID 3803419 (https://pubmed.ncbi.nlm.nih.gov/3803419). S2CID 41004554 (https://api.semanticscholar.org/CorpusID:41004554).

19. Dilger RN, Baker DH (July 2007). "Oral *N*-acetyl-L-cysteine is a safe and effective precursor of cysteine". *Journal of Animal Science*. **85** (7): 1712–1718. doi:10.2527/jas.2006-835 (https://doi.org/10.2527%2Fjas.2006-835). PMID 17371789 (https://pubmed.ncbi.nlm.nih.gov/17371789).
20. Kanter MZ (October 2006). "Comparison of oral and i.v. acetylcysteine in the treatment of acetaminophen poisoning". *American Journal of Health-System Pharmacy*. **63** (19): 1821–1827. doi:10.2146/ajhp060050 (https://doi.org/10.2146%2Fajhp060050). PMID 16990628 (https://pubmed.ncbi.nlm.nih.gov/16990628). S2CID 9209528 (https://api.semanticscholar.org/CorpusID:9209528).
21. Dawson AH, Henry DA, McEwen J (March 1989). "Adverse reactions to *N*-acetylcysteine during treatment for paracetamol poisoning". *The Medical Journal of Australia*. **150** (6): 329–331. doi:10.5694/j.1326-5377.1989.tb136496.x (https://doi.org/10.5694%2Fj.1326-5377.1989.tb136496.x). PMID 2716644 (https://pubmed.ncbi.nlm.nih.gov/2716644). S2CID 40296724 (https://api.semanticscholar.org/CorpusID:40296724).
22. Bailey B, McGuigan MA (June 1998). "Management of anaphylactoid reactions to intravenous *N*-acetylcysteine". *Annals of Emergency Medicine*. **31** (6): 710–715. doi:10.1016/S0196-0644(98)70229-X (https://doi.org/10.1016%2FS0196-0644%2898%2970229-X). PMID 9624310 (https://pubmed.ncbi.nlm.nih.gov/9624310).
23. Schmidt LE, Dalhoff K (January 2001). "Risk factors in the development of adverse reactions to *N*-acetylcysteine in patients with paracetamol poisoning" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2014432). *British Journal of Clinical Pharmacology*. **51** (1): 87–91. doi:10.1046/j.1365-2125.2001.01305.x (https://doi.org/10.1046%2Fj.1365-2125.2001.01305.x). PMC 2014432 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2014432). PMID 11167669 (https://pubmed.ncbi.nlm.nih.gov/11167669).
24. Lynch RM, Robertson R (January 2004). "Anaphylactoid reactions to intravenous *N*-acetylcysteine: a prospective case controlled study". *Accident and Emergency Nursing*. **12** (1): 10–15. doi:10.1016/j.aaen.2003.07.001 (https://doi.org/10.1016%2Fj.aaen.2003.07.001). PMID 14700565 (https://pubmed.ncbi.nlm.nih.gov/14700565).
25. Rossi S, editor. Australian Medicines Handbook 2006. Adelaide: Australian Medicines Handbook; 2006.
26. Tam J, Nash EF, Ratjen F, Tullis E, Stephenson A (12 July 2013). "Nebulized and oral thiol derivatives for pulmonary disease in cystic fibrosis" (http://www.repository.heartofengland.nhs.uk/157/1/Nebulized%20and%20oral%20thiol%20derivatives%20for%20pulmonary%20disease%20in%20cystic%20fibrosis..pdf) (PDF). *The Cochrane Database of Systematic Reviews* (7): CD007168. doi:10.1002/14651858.CD007168.pub3 (https://doi.org/10.1002%2F14651858.CD007168.pub3). PMC 8078644 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8078644). PMID 23852992 (https://pubmed.ncbi.nlm.nih.gov/23852992).
27. Grandjean EM, Berthet P, Ruffmann R, Leuenberger P (February 2000). "Efficacy of oral long-term *N*-acetylcysteine in chronic bronchopulmonary disease: a meta-analysis of published double-blind, placebo-controlled clinical trials". *Clinical Therapeutics*. **22** (2): 209–21. doi:10.1016/S0149-2918(00)88479-9 (https://doi.org/10.1016%2FS0149-2918%2800%2988479-9). PMID 10743980 (https://pubmed.ncbi.nlm.nih.gov/10743980).
28. Stey C, Steurer J, Bachmann S, Medici TC, Tramèr MR (August 2000). "The effect of oral *N*-acetylcysteine in chronic bronchitis: a quantitative systematic review" (https://doi.org/10.1034%2Fj.1399-3003.2000.16b12.x). *The European Respiratory Journal*. **16** (2): 253–262. doi:10.1034/j.1399-3003.2000.16b12.x (https://doi.org/10.1034%2Fj.1399-3003.2000.16b12.x). PMID 10968500 (https://pubmed.ncbi.nlm.nih.gov/10968500).

29. Poole PJ, Black PN (May 2001). "Oral mucolytic drugs for exacerbations of chronic obstructive pulmonary disease: systematic review" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC31920). *BMJ*. **322** (7297): 1271–1274. doi:10.1136/bmj.322.7297.1271 (https://doi.org/10.1136%2Fbmj.322.7297.1271). PMC 31920 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC31920). PMID 11375228 (https://pubmed.ncbi.nlm.nih.gov/11375228).
30. Pistolesi V, Regolisti G, Morabito S, Gandolfini I, Corrado S, Piotti G, Fiaccadori E (December 2018). "Contrast medium induced acute kidney injury: a narrative review". *Journal of Nephrology*. **31** (6): 797–812. doi:10.1007/s40620-018-0498-y (https://doi.org/10.1007%2Fs40620-018-0498-y). PMID 29802583 (https://pubmed.ncbi.nlm.nih.gov/29802583). S2CID 44128861 (https://api.semanticscholar.org/CorpusID:44128861).
31. "Hemorrhagic Cystitis Treatment & Management: Approach Considerations, Clot Evacuation, Bladder Irrigation Agents" (https://emedicine.medscape.com/article/2056130-treatment#d12). 5 December 2019. Retrieved 18 December 2019.
32. Bartoli F, Cavaleri D, Bachi B, Moretti F, Riboldi I, Crocamo C, Carrà G (September 2021). "Repurposed drugs as adjunctive treatments for mania and bipolar depression: A meta-review and critical appraisal of meta-analyses of randomized placebo-controlled trials". *Journal of Psychiatric Research*. **143**: 230–238. doi:10.1016/j.jpsychires.2021.09.018 (https://doi.org/10.1016%2Fj.jpsychires.2021.09.018). PMID 34509090 (https://pubmed.ncbi.nlm.nih.gov/34509090). S2CID 237485915 (https://api.semanticscholar.org/CorpusID:237485915).
33. Dean O, Giorlando F, Berk M (March 2011). "*N*-Acetylcysteine in psychiatry: current therapeutic evidence and potential mechanisms of action" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3044191). *Journal of Psychiatry & Neuroscience*. **36** (2): 78–86. doi:10.1503/jpn.100057 (https://doi.org/10.1503%2Fjpn.100057). PMC 3044191 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3044191). PMID 21118657 (https://pubmed.ncbi.nlm.nih.gov/21118657).
34. Berk M, Malhi GS, Gray LJ, Dean OM (March 2013). "The promise of *N*-acetylcysteine in neuropsychiatry". *Trends in Pharmacological Sciences*. **34** (3): 167–177. doi:10.1016/j.tips.2013.01.001 (https://doi.org/10.1016%2Fj.tips.2013.01.001). PMID 23369637 (https://pubmed.ncbi.nlm.nih.gov/23369637).
35. Bavarsad Shahripour R, Harrigan MR, Alexandrov AV (March 2014). "*N*-Acetylcysteine (NAC) in neurological disorders: mechanisms of action and therapeutic opportunities" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3967529). *Brain and Behavior*. **4** (2): 108–122. doi:10.1002/brb3.208 (https://doi.org/10.1002%2Fbrb3.208). PMC 3967529 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3967529). PMID 24683506 (https://pubmed.ncbi.nlm.nih.gov/24683506).
36. Slattery J, Kumar N, Delhey L, Berk M, Dean O, Spielholz C, Frye R (August 2015). "Clinical trials of *N*-acetylcysteine in psychiatry and neurology: A systematic review" (https://doi.org/10.1016%2Fj.neubiorev.2015.04.015). *Neuroscience and Biobehavioral Reviews*. **55**: 294–321. doi:10.1016/j.neubiorev.2015.04.015 (https://doi.org/10.1016%2Fj.neubiorev.2015.04.015). PMID 25957927 (https://pubmed.ncbi.nlm.nih.gov/25957927).
37. Berk M, Dean OM, Cotton SM, Jeavons S, Tanious M, Kohlmann K, Hewitt K, Moss K, Allwang C, Schapkaitz I, Robbins J, Cobb H, Ng F, Dodd S, Bush AI, Malhi GS (June 2014). "The efficacy of adjunctive *N*-acetylcysteine in major depressive disorder: a double-blind, randomized, placebo-controlled trial" (https://doi.org/10.4088%2FJCP.13m08454). *The Journal of Clinical Psychiatry*. **75** (6): 628–636. doi:10.4088/JCP.13m08454 (https://doi.org/10.4088%2FJCP.13m08454). PMID 25004186 (https://pubmed.ncbi.nlm.nih.gov/25004186).
38. Oliver G, Dean O, Camfield D, Blair-West S, Ng C, Berk M, Sarris J (April 2015). "*N*-Acetylcysteine in the treatment of obsessive compulsive and related disorders: a systematic review" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4423164). *Clinical Psychopharmacology and Neuroscience*. **13** (1): 12–24. doi:10.9758/cpn.2015.13.1.12 (https://doi.org/10.9758%2Fcpn.2015.13.1.12). PMC 4423164 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4423164). PMID 25912534 (https://pubmed.ncbi.nlm.nih.gov/25912534).

39. Samuni Y, Goldstein S, Dean OM, Berk M (August 2013). "The chemistry and biological activities of *N*-acetylcysteine". *Biochimica et Biophysica Acta (BBA) – General Subjects*. **1830** (8): 4117–4129. doi:10.1016/j.bbagen.2013.04.016 (https://doi.org/10.1016%2Fj.bbagen.2013.04.016). hdl:11343/43874 (https://hdl.handle.net/11343%2F43874). PMID 23618697 (https://pubmed.ncbi.nlm.nih.gov/23618697). S2CID 2567773 (https://api.semanticscholar.org/CorpusID:2567773).
40. Minarini A, Ferrari S, Galletti M, Giambalvo N, Perrone D, Rioli G, Galeazzi GM (2 November 2016). "*N*-Acetylcysteine in the treatment of psychiatric disorders: current status and future prospects". *Expert Opinion on Drug Metabolism & Toxicology*. **13** (3): 279–292. doi:10.1080/17425255.2017.1251580 (https://doi.org/10.1080%2F17425255.2017.1251580). hdl:11380/1116466 (https://hdl.handle.net/11380%2F1116466). PMID 27766914 (https://pubmed.ncbi.nlm.nih.gov/27766914). S2CID 20873065 (https://api.semanticscholar.org/CorpusID:20873065).
41. McClure EA, Gipson CD, Malcolm RJ, Kalivas PW, Gray KM (2014). "Potential role of *N*-acetylcysteine in the management of substance use disorders" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4009342). *CNS Drugs*. **28** (2): 95–106. doi:10.1007/s40263-014-0142-x (https://doi.org/10.1007%2Fs40263-014-0142-x). PMC 4009342 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4009342). PMID 24442756 (https://pubmed.ncbi.nlm.nih.gov/24442756).
42. Buijtels PC, Petit PL (July 2005). "Comparison of NaOH–*N*-acetyl cysteine and sulfuric acid decontamination methods for recovery of mycobacteria from clinical specimens". *Journal of Microbiological Methods*. **62** (1): 83–88. doi:10.1016/j.mimet.2005.01.010 (https://doi.org/10.1016%2Fj.mimet.2005.01.010). PMID 15823396 (https://pubmed.ncbi.nlm.nih.gov/15823396).
43. Geiler J, Michaelis M, Naczk P, Leutz A, Langer K, Doerr HW, Cinatl J (February 2010). "*N*-Acetyl-L-cysteine (NAC) inhibits virus replication and expression of pro-inflammatory molecules in A549 cells infected with highly pathogenic H5N1 influenza A virus" (https://hal.archives-ouvertes.fr/hal-00538093/file/PEER_stage2_10.1016%252Fj.bcp.2009.08.025.pdf) (PDF). *Biochemical Pharmacology*. **79** (3): 413–420. doi:10.1016/j.bcp.2009.08.025 (https://doi.org/10.1016%2Fj.bcp.2009.08.025). PMID 19732754 (https://pubmed.ncbi.nlm.nih.gov/19732754).
44. Aslam S, Darouiche RO (September 2011). "Role of antibiofilm-antimicrobial agents in controlling device-related infections" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3251652). *The International Journal of Artificial Organs*. **34** (9): 752–758. doi:10.5301/ijao.5000024 (https://doi.org/10.5301%2Fijao.5000024). PMC 3251652 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3251652). PMID 22094553 (https://pubmed.ncbi.nlm.nih.gov/22094553).
45. Garrett CE, Prasad K (2004). "The Art of Meeting Palladium Specifications in Active Pharmaceutical Ingredients Produced by Pd-Catalyzed Reactions". *Advanced Synthesis & Catalysis*. **346** (8): 889–900. doi:10.1002/adsc.200404071 (https://doi.org/10.1002%2Fadsc.200404071). S2CID 94929244 (https://api.semanticscholar.org/CorpusID:94929244).
46. "Acetylcysteine" (https://livertox.nih.gov/Acetylcysteine.htm), *livertox.nih.gov*, retrieved 26 April 2019
47. "Mucomyst Package Insert" (http://dailymed.nlm.nih.gov/dailymed/lookup.cfm?setid=d2dc24f3-3ad7-4c6c-8e9f-7202d9a146f7). Archived (https://web.archive.org/web/20140421050640/http://dailymed.nlm.nih.gov/dailymed/lookup.cfm?setid=d2dc24f3-3ad7-4c6c-8e9f-7202d9a146f7) from the original on 21 April 2014. Retrieved 20 April 2014.
48. Palmer LA, Doctor A, Chhabra P, Sheram ML, Laubach VE, Karlinsey MZ, Forbes MS, Macdonald T, Gaston B (September 2007). "*S*-Nitrosothiols signal hypoxia-mimetic vascular pathology" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1952618). *The Journal of Clinical Investigation*. **117** (9): 2592–2601. doi:10.1172/JCI29444 (https://doi.org/10.1172%2FJCI29444). PMC 1952618 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1952618). PMID 17786245 (https://pubmed.ncbi.nlm.nih.gov/17786245).

49. Hildebrandt W, Alexander S, Bärtsch P, Dröge W (March 2002). "Effect of *N*-acetyl-cysteine on the hypoxic ventilatory response and erythropoietin production: linkage between plasma thiol redox state and O_2 chemosensitivity" (https://doi.org/10.1182%2Fblood.V99.5.1552). *Blood*. **99** (5): 1552–5. doi:10.1182/blood.V99.5.1552 (https://doi.org/10.1182%2Fblood.V99.5.1552). PMID 11861267 (https://pubmed.ncbi.nlm.nih.gov/11861267). S2CID 24375953 (https://api.semanticscholar.org/CorpusID:24375953).
50. Wang AL, Wang JP, Wang H, Chen YH, Zhao L, Wang LS, Wei W, Xu DX (March 2006). "A dual effect of *N*-acetylcysteine on acute ethanol-induced liver damage in mice". *Hepatology Research*. **34** (3): 199–206. doi:10.1016/j.hepres.2005.12.005 (https://doi.org/10.1016%2Fj.hepres.2005.12.005). PMID 16439183 (https://pubmed.ncbi.nlm.nih.gov/16439183).
51. "Product Information: Aceradote® Concentrated Injection" (https://www.ebs.tga.gov.au/ebs/picmi/picmirepository.nsf/pdf?OpenAgent&id=CP-2010-PI-03960-3) (PDF). *TGA eBusiness Services*. Phebra Pty Ltd. 16 January 2013. Archived (https://web.archive.org/web/20170908143219/https://www.ebs.tga.gov.au/ebs/picmi/picmirepository.nsf/pdf?OpenAgent&id=CP-2010-PI-03960-3) from the original on 8 September 2017. Retrieved 8 November 2013.
52. Steullet P, Neijt HC, Cuénod M, Do KQ (2006). "Synaptic plasticity impairment and hypofunction of NMDA receptors induced by glutathione deficit: Relevance to schizophrenia". *Neuroscience*. **137** (3): 807–819. doi:10.1016/j.neuroscience.2005.10.014 (https://doi.org/10.1016%2Fj.neuroscience.2005.10.014). ISSN 0306-4522 (https://www.worldcat.org/issn/0306-4522). PMID 16330153 (https://pubmed.ncbi.nlm.nih.gov/16330153). S2CID 1417873 (https://api.semanticscholar.org/CorpusID:1417873).
53. Varga V, Jenei Z, Janáky R, Saransaari P, Oja SS (1997). "Glutathione Is an Endogenous Ligand of Rat Brain *N*-Methyl-D-Aspartate (NMDA) and 2-Amino-3-Hydroxy-5-Methyl-4-Isoxazolepropionate (AMPA) Receptors". *Neurochemical Research*. **22** (9): 1165–1171. doi:10.1023/A:1027377605054 (https://doi.org/10.1023%2FA%3A1027377605054). ISSN 0364-3190 (https://www.worldcat.org/issn/0364-3190). PMID 9251108 (https://pubmed.ncbi.nlm.nih.gov/9251108). S2CID 24024090 (https://api.semanticscholar.org/CorpusID:24024090).
54. Oja SS (2000). "Modulation of glutamate receptor functions by glutathione". *Neurochemistry International*. **37** (2–3): 299–306. doi:10.1016/S0197-0186(00)00031-0 (https://doi.org/10.1016%2FS0197-0186%2800%2900031-0). ISSN 0197-0186 (https://www.worldcat.org/issn/0197-0186). PMID 10812215 (https://pubmed.ncbi.nlm.nih.gov/10812215). S2CID 44380765 (https://api.semanticscholar.org/CorpusID:44380765).
55. Lavoie S, Murray MM, Deppen P, Knyazeva MG, Berk M, Boulat O, Bovet P, Bush AI, Conus P, Copolov D, Fornari E, Meuli R, Solida A, Vianin P, Cuénod M, Buclin T, Do KQ (August 2008). "Glutathione precursor, *N*-acetyl-cysteine, improves mismatch negativity in schizophrenia patients" (https://doi.org/10.1038%2Fsj.npp.1301624). *Neuropsychopharmacology*. **33** (9): 2187–2199. doi:10.1038/sj.npp.1301624 (https://doi.org/10.1038%2Fsj.npp.1301624). PMID 18004285 (https://pubmed.ncbi.nlm.nih.gov/18004285).
56. Dodd S, Dean O, Copolov DL, Malhi GS, Berk M (December 2008). "*N*-Acetylcysteine for antioxidant therapy: pharmacology and clinical utility". *Expert Opinion on Biological Therapy*. **8** (12): 1955–1962. doi:10.1517/14728220802517901 (https://doi.org/10.1517%2F14728220802517901). PMID 18990082 (https://pubmed.ncbi.nlm.nih.gov/18990082). S2CID 74736842 (https://api.semanticscholar.org/CorpusID:74736842).
57. Kupchik YM, Moussawi K, Tang XC, Wang X, Kalivas BC, Kolokithas R, Ogburn KB, Kalivas PW (June 2012). "The effect of *N*-acetylcysteine in the nucleus accumbens on neurotransmission and relapse to cocaine" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3340445). *Biological Psychiatry*. **71** (11): 978–986. doi:10.1016/j.biopsych.2011.10.024 (https://doi.org/10.1016%2Fj.biopsych.2011.10.024). PMC 3340445 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3340445). PMID 22137594 (https://pubmed.ncbi.nlm.nih.gov/22137594).

58. "*N*-Acetyl-L-cysteine | $C_5H_9NO_3S$" (https://pubchem.ncbi.nlm.nih.gov/compound/N-Acetyl-L-cysteine#section=Chemical-and-Physical-Properties). *PubChem*. Archived (https://web.archive.org/web/20160816171151/https://pubchem.ncbi.nlm.nih.gov/compound/N-Acetyl-L-cysteine#section=Chemical-and-Physical-Properties) from the original on 16 August 2016. Retrieved 22 July 2016.
59. "Amazon confirms plans on removing NAC supplements" (https://www.naturalproductsinsider.com/regulatory/amazon-confirms-plans-removing-nac-supplements).
60. "Amazon reportedly removes NAC-containing dietary supplements" (https://www.naturalproductsinsider.com/regulatory/amazon-reportedly-removes-nac-containing-dietary-supplements).
61. "WARNING LETTER benjaminmcevoy.com" (https://www.fda.gov/inspections-compliance-enforcement-and-criminal-investigations/warning-letters/benjaminmcevoycom-607149-05142020).
62. "FDA Sends Warning Letters to Seven Companies Illegally Selling Hangover Products" (https://www.fda.gov/food/cfsan-constituent-updates/fda-sends-warning-letters-seven-companies-illegally-selling-hangover-products).
63. "FDA Releases Draft Guidance on Enforcement Discretion for Certain NAC Products" (https://www.fda.gov/food/cfsan-constituent-updates/fda-releases-draft-guidance-enforcement-discretion-certain-nac-products).
64. Head SI (29 October 2017). "Antioxidant therapy in a mouse model of Duchenne muscular dystrophy: some promising results but with a weighty caveat" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5709324). *The Journal of Physiology*. **595** (23): 7015. doi:10.1113/jp275232 (https://doi.org/10.1113%2Fjp275232). ISSN 0022-3751 (https://www.worldcat.org/issn/0022-3751). PMC 5709324 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5709324). PMID 29034480 (https://pubmed.ncbi.nlm.nih.gov/29034480).
65. Gu F, Chauhan V, Chauhan A (January 2015). "Glutathione redox imbalance in brain disorders". *Current Opinion in Clinical Nutrition and Metabolic Care*. **18** (1): 89–95. doi:10.1097/MCO.0000000000000134 (https://doi.org/10.1097%2FMCO.0000000000000134). PMID 25405315 (https://pubmed.ncbi.nlm.nih.gov/25405315). S2CID 25333289 (https://api.semanticscholar.org/CorpusID:25333289).
66. Bachert C, Hörmann K, Mösges R, Rasp G, Riechelmann H, Müller R, Luckhaupt H, Stuck BA, Rudack C (March 2003). "An update on the diagnosis and treatment of sinusitis and nasal polyposis" (https://doi.org/10.1034%2Fj.1398-9995.2003.02172.x). *Allergy*. **58** (3): 176–191. doi:10.1034/j.1398-9995.2003.02172.x (https://doi.org/10.1034%2Fj.1398-9995.2003.02172.x). PMID 12653791 (https://pubmed.ncbi.nlm.nih.gov/12653791). S2CID 35319457 (https://api.semanticscholar.org/CorpusID:35319457).
67. Aitio ML (January 2006). "*N*-Acetylcysteine – passe-partout or much ado about nothing?" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1884975). *British Journal of Clinical Pharmacology*. **61** (1): 5–15. doi:10.1111/j.1365-2125.2005.02523.x (https://doi.org/10.1111%2Fj.1365-2125.2005.02523.x). PMC 1884975 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1884975). PMID 16390346 (https://pubmed.ncbi.nlm.nih.gov/16390346).
68. Williamson J, Doig WM, Forrester JV, Tham MH, Wilson T, Whaley K, Dick WC (September 1974). "Management of the dry eye in Sjogren's syndrome" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1215027). *The British Journal of Ophthalmology*. **58** (9): 798–805. doi:10.1136/bjo.58.9.798 (https://doi.org/10.1136%2Fbjo.58.9.798). PMC 1215027 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1215027). PMID 4433493 (https://pubmed.ncbi.nlm.nih.gov/4433493).
69. Lindblad AC, et al. (November–December 2011). "The efficacy of *N*-acetylcysteine to protect the human cochlea from subclinical hearing loss caused by impulse noise: a controlled trial" (https://doi.org/10.4103%2F1463-1741.90293). *Noise Health*. **13** (55): 392–401. doi:10.4103/1463-1741.90293 (https://doi.org/10.4103%2F1463-1741.90293). PMID 22122955 (https://pubmed.ncbi.nlm.nih.gov/22122955).

70. Edwards MJ, Hargreaves IP, Heales SJ, Jones SJ, Ramachandran V, Bhatia KP, Sisodiya S (November 2002). "*N*-acetylcysteine and Unverricht-Lundborg disease: variable response and possible side effects". *Neurology*. **59** (9): 1447–1449. doi:10.1212/wnl.59.9.1447 (https://doi.org/10.1212%2Fwnl.59.9.1447). PMID 12427904 (https://pubmed.ncbi.nlm.nih.gov/12427904).
71. *Ataxia with Identified Genetic and Biochemical Defects (https://emedicine.medscape.com/article/1153370-overview)* at eMedicine
72. d. o.; Stankewicz H (10 September 2017). "Use of NAC in Alleviation of Hangover Symptoms – Study Results" (https://clinicaltrials.gov/ct2/show/results/NCT02541422?sect=X70156#outcome1). *clinicaltrials.gov*.
73. De Flora S, Grassi C, Carati L (1 July 1997). "Attenuation of influenza-like symptomatology and improvement of cell-mediated immunity with long-term *N*-acetylcysteine treatment" (https://doi.org/10.1183%2F09031936.97.10071535). *European Respiratory Journal*. **10** (7): 1535–1541. doi:10.1183/09031936.97.10071535 (https://doi.org/10.1183%2F09031936.97.10071535). PMID 9230243 (https://pubmed.ncbi.nlm.nih.gov/9230243).
74. "*N*-Acetylcysteine as Adjuvant Therapy for COVID-19 – A Perspective on the Current State of the Evidence" (https://www.dovepress.com/n-acetylcysteine-as-adjuvant-therapy-for-covid-19--a-perspective-on-th-peer-reviewed-fulltext-article-JIR).
75. Assimakopoulos SF, Aretha D, Komninos D, Dimitropoulou D, Lagadinou M, Leonidou L, Oikonomou I, Mouzaki A, Marangos M (2021). "*N*-Acetyl-cysteine reduces the risk for mechanical ventilation and mortality in patients with COVID-19 pneumonia: a two-center retrospective cohort study" (https://pubmed.ncbi.nlm.nih.gov/34182881/). *Infectious Diseases (London, England)*. **53** (11): 847–854. doi:10.1080/23744235.2021.1945675 (https://doi.org/10.1080%2F23744235.2021.1945675). PMID 34182881 (https://pubmed.ncbi.nlm.nih.gov/34182881). S2CID 235673520 (https://api.semanticscholar.org/CorpusID:235673520).
76. Kapur A, Sharma M, Sageena G (2022). "Therapeutic potential of *N*-acetyl cysteine during COVID-19 epoch" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8966593). *World Journal of Virology*. **11** (2): 104–106. doi:10.5501/wjv.v11.i2.104 (https://doi.org/10.5501%2Fwjv.v11.i2.104). PMC 8966593 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8966593). PMID 35433335 (https://pubmed.ncbi.nlm.nih.gov/35433335).

External links

- "Acetylcysteine" (https://druginfo.nlm.nih.gov/drugportal/name/acetylcysteine). *Drug Information Portal*. U.S. National Library of Medicine.