## **Alcohol and Head and Neck Cancer**

Subjects: Oncology | Medicine, Research & Experimental Contributor: Sergio Terracina , Carla Petrella

As suggested from recent findings, the role of alcohol in HNC seems to be broader than that of a simple risk factor. In this entry, authors report evidence from past studies to clarify the role of alcohol consumption in head and neck cancer (HNC) onset. Moreover, we further explore the role of oral microbiota, oxidative stress and genetic expression alterations due to alcohol drinking. Although alcohol is not the exclusive risk factor for HNC carcinogenesis, it plays a major role in the etiopathogenesis of both primary tumors and their recurrences, especially by means of ethanol and its metabolic products. Alcohol modifies oral microbiota, enhances intracellular oxidative stress, expose epithelial cells to carcinogens and alters cellular genetic expressions by promoting epigenetic mutations, DNA damage, and inaccurate DNA repair related to the formation of DNA adducts. The relationship between alcohol and HNC has been well established but, unfortunately, there is no clear threshold effect of alcohol for oncogenic patients, so that prevention and monitoring with long-term markers of alcohol consumption (especially those detected in the hair) that relay information on the actual alcohol drinking habits, seem to be the most effective ways to contrast its prevalence (and complications) in HNC drinker-patients. These conclusions seem to be especially important nowadays since, despite the established association between alcohol and HNC, a concerning pattern of alcohol consumption misconducts has been found in both in the general population and HNC survivors. Interestingly, evidence that we report on HNC etiopathogenesis suggests a key role of polyphenols and alkylating agents for patient management, especially in case of heavy chronic drinkers.

oral microbiota alcohol alkylating agents epigenetics growth factors

## 1. Introduction

Worldwide, head and neck cancer (HNC) accounts for more than 890,000 cases and 450,000 deaths annually <sup>[1]</sup>. Head and neck cancer is a malignancy, associated with the advanced stage at presentation and heavy outcomes (mean 5-year survival <50%), that occurs more often in the lips and oral cavity, nasopharynx, oropharynx, hypopharynx, and larynx; squamous cell carcinoma (SCC) represents the prevalent histology <sup>[2][3]</sup>.

Alcohol abuse may result in significant mental <sup>[4][5][6][7][8]</sup> or physical health problems <sup>[9][10][11][12]</sup>. Furthermore, when consumed during gestation, it may induce severe damage to the newborns <sup>[13][14][15][16][17][18][19][20]</sup>. Alcohol is a well-known carcinogen compound but it is still underestimated in the general population, partially also because of the alcohol industry's extensive misrepresentation of evidence about the alcohol-related risk of cancer <sup>[21][22]</sup>. Alcohol drinking, together with tobacco smoking, and human papillomavirus (HPV) infection (**Table 1**) are HNC-recognized risk factors <sup>[23][24][25][26]</sup>. Interestingly, the role of alcohol in HNC seems to be broader than that of a simple risk factor, as suggested from recent findings which highlighted how significant inverse association exists

between alcohol drinking and prognosis among HNC patients [27][28]. It has been reported that, in 2012, a total of 203,511 cases of the oral cavity, oropharyngeal, hypopharyngeal, and larynx cancer were attributable to alcohol consumption (179,559 men and 23,952 women) <sup>[29]</sup>. The proportion of HNC cases attributable to alcohol is still increasing, emphasizing the importance of alcohol consumption limitation to prevent HNC. Alcohol use among HNC survivors negatively impacts patient outcomes and is an important risk factor for recurrent and second primary tumors. Despite recommendations from several cancer societies, alcohol consumption remains a common problem in this population. <sup>[30]</sup>. The estimate of the real alcohol consumption (based not only on what the patient declared during the anamnesis) would be of support in consolidating the correlation with the onset of HNC.

Table 1. Major differences between HPV + and HPV - HNSCC (mainly related to alcohol abuse and smoke). Alcohol is a major determinant of aggressive HNCs. HNSCC, head and neck squamous cell carcinomas; HPV, human papillomavirus.

	HPV + HNSCC	HPV - HNSCC
Main risk factors	Sexual contact, HPV type 16 and 18	Alcohol and smoking
Tumor site	Oropharynx	Non-oropharyngeal sites
Histopathology	Basaloid, non- keratinizing, poorly differentiated	Keratinizing, moderately differentiated
Main carcinogenic factor	Viral protein E6 and E7 action	DNA damage and inaccurate DNA repair promoted by alcohol catabolism and smoke carcinogen components action
Responsiveness to chemoradiation	Better than HPV - HNSCC	Worse than HPV + HNSCC
Prognosis	Better than HPV - HNSCC	Worse than HPV + HNSCC
Prevention	HPV vaccine, condom	Alcohol and smoking abstinence

## References

1. Sung, H.; Ferlay, J.; Siegel, R.L.; Laversanne, M.; Soerjomataram, I.; Jemal, A.; Bray, F. Global

2 a He adtiating 2 We Cko Bandes tiantes A cook of and Mortality Worldwide for 36 Cancers in 185 Countries. CA Cancer J. Clin. 2021, 71, 209-249.

**2.1. Diagnosis and Treatments** 2. Kawakita, D.; Matsuo, K. Alcohol and head and neck cancer. Cancer Metastasis Rev. 2017, 36,

The HINC diagnosis usually includes laryngoscopy, imaging [Positron emission tomography/X-ray computed tomoer and he compare the series of the seri technologye arosuraaval thad good posted rate to reprise parties to strate to standard the second and neck on cology has been perenvieed hole on decaline and weir. or the mais in or the transferring the states of the transferring malignance derivatives, such as circulating tumor DNA, intact circulating tumor cells (CTCs), and exosomes in patients' blood, Hanbeld dia uil bi Basta glie secon Attibian of et Roossidle, appretes biotan Fro Ceana an ostics, treate central Fringe, and

postAre Great a stir Will a this patient of the pretangent and a start of a look of the pretangent and the pretangent of a look of the pretangent of a look of the pretangent of a look of the pretangent of the p

under detoxification. Physiol. Behav. 2019, 198, 67-75.

Treatment possibilities include tumor resection (primary and/or secondary tumor), radical neck dissection, 5. Cecçanti, M.; Hamilton, D.; Coriale, G.; Carito, V.; Aloe, L.; Chaldakov, G.; Romeo, M.; Iannitelli, immunotherapy, radiotherapy, checkpoint inhibitors (mainly targeting the cytotoxic T-lymphocyte-associated protein A.; Fiore, M. Spatial learning in men undergoing alcohol detoxification. Physiol. Behav. 2015, 149 (CTLA-4)), programmed cell death protein 1 (PD-1), programmed death-ligand 1 (PD-L1), and chemotherapy (1991). tom Georgante, Modi Contaile, have Hasightoina D. Arogoasito, iMpacooouttelloo Rent Scales as Bure Ciatine, S. induction checrodazzoy Centries in a, M.P.; Chaldakov, G.N.; et al. Virtual Morris task responses in individuals in

an abstinence phase from alcohol. Can. J. Physiol. Pharmacol. 2018, 96, 128–136.

It is believed that the majority of oral cancers develop from oral potentially malignant lesions (OPMLs) <sup>[47]</sup>. Though 7. Coriale, G.: Battagliese, G.: Pisciotta, F.: Attilia, M.L.: Porrari, R.: De Rosa, F.: Vitali, M.: Carito, V.: they can be easily detected during screening, risk stratification is difficult. During screening, clinicians often find it Messina, M.P.: Greco, A.: et al. Behavioral responses in people affected by alcohol use disorder difficult to distinguish OPMLs from benign lesions, and predicting OPMLs at risk of malignant transformation could and psychiatric comorbidity: Correlations with addiction severity. Ann. Dell'Istituto Super. Sanita be particularly challenging <sup>[47]</sup>. INA aneuploidy has been known to be a marker of malignancy in a number of sites, 2019, 55, 131–142. including the oral cavity <sup>[47]</sup>. Indeed, DNA ploidy and chromatin organization of cells collected from OPMLs can

i8e Gioriakso G. a Gentraselbf Scopestaglieseera vedesfinior 🕮. Filoisemtiniov Bave keu Kau G. eGaleccli Aici Rallio

triable. nightiliiak 10 P.M.L.M. essiloae Mo Rowely al will invisiologicals Responsed ego breasting statistical as invidualized the

bur Affectedeby here of the source of the state of the st

a 5ed-20d-ed 290-fold elevated risk, much earlier onset, and limited therapeutic options for oral SCC compared with

the general population), a careful inspection of the oral cavity associated with brush biopsy-based cytology could 9. Ceci, F.M., Ceccanti, M.; Petrella, C.; Vitali, M.; Messina, M.P.; Chaldakov, G.N.; Greco, A.; Ralli, identify visible oral lesions, either malignant or potentially malignant, that warrant treatment [49]. M., Lucarelli, M.; Angeloni, A.; et al. Alcohol Drinking, Apolipoprotein Polymorphisms and the Risk

2.2. Arkylating Agents

10. Ceccanti, M.; Inghilleri, M.; Attilia, M.L.; Raccah, R.; Fiore, M.; Zangen, A. Deep TMS on Because of the mentioned key role of genetic and epigenetic alterations in HNC, treatment protocols still include alterations. Effects on cortisolemia and dopamine pathway modulation. A pilot study. Can. J. the use of alkylating agents (AAs) AAs are a heterogeneous class of drugs that interfere with the cell's DNA and Physiol. Pharmacol. 2015. 93. 283–290. inhibit cancer cells' growth, playing a major role in HNC <sup>[50]</sup>. These genotoxic agents modify the DNA by adding 1 Jin Cieccantik, Mgroup to the guarline base of DNA at the humber of starogen atom of the pumerang, either directly or Santinie B. Attilia, M. L. Hypertension in early alcoholiw itheraval in chronic alcoholics. Alcohol effects targeting many organs and apparats, such as the gastrointestinal tract, bone marrow, testicles, and ovaries; chexnetheraerusicereadminat, of HNA cereesiebheinelationartheraethereasin rechteren nzerestatio corser. 844 the focus is gradually shifting to non-conventional systemic chemotherapy, especially targeted therapy and 13. Fiore, M.; Petrella, C.; Coriale, G.; Rosso, P.; Fico, E.; Ralli, M.; Greco, A.; De Vincentiis, M.; immunotherapy, which affect the tumor microenvironment and have a potentially favorable impact on HNC Minni, A.; Polimeni, A.; et al. Markers of Neuroinflammation in the Serum of Prepubertal Children management with Fetal Alcohol Spectrum Disorders. CNS Neurol. Disord. Drug Targets 2021, 20, 1.

12.3 Alcoho Abusa Detectionani, L.; Messina, M.P.; Lucarelli, M.; Vitali, M.; De Persis, S.;

Greco, A.; Minni, A.; Polimeni, A.; et al. Transgenerational Abnormalities Induced by Paternal Despite the numerous proposed biomarkers in many studies, no laboratory test is sufficiently reliable alone to Preconceptual Alcohol Drinking. Findings from Humans and Animal Models. Curr. support a diagnosis of alcohol use disorder (AUD) <sup>[58][59]</sup>. Sensitivity and specificity should be high for alcohol Neuropharmacol. 2021, 19, 1.

abuse biomarkers, but in reality, they mostly fluctuate considerably and depend on the involved population.

15urtiecoardi, tMa.; deacouncellos Rhoutarietoe d. a Ciatrièridea; Feoraguntiption; deiacowatz both Cchirk/Hacetin estimation estimation and the experimentation of the end of t

- 17et Catille, Ki; Georgeti, the Fastaguiti, years Coepetrally, Bn; the figh Br; TirassaaP; Fierat M. Nation of the content of the series of th
- 18: OPEFAGUIT, C.; Merrino, e.; Baildynese, C., Prikersni, M.C., Bailbard, C.; Carito, M.; Messina, M.P.; These areas of the second states of the second st
- 19. Corjale, G.: Fiorentino, D.: Di Lauro, F.: Marchitelli, R.: Scalese, B.: Fiore, M.: Maviglia, M.: included in screening tests for injured of at-risk for alcohol abuse people (including pregnant women) to investigate Ceccanti, M. Fetal Alcohol Spectrum Disorder (FASD): Neurobehavioral profile, indications for the possible association between residual alcohol effects and injuries, and to verify alcohol abstinence in cases of diagnosis and treatment of the psichiatr. 2013, 48, 359–369.
- Fetal alcohol spectrum disorders awareness in health professionals: Implications for psychiatry. Riv. Psichiatr. 2020, 55, 79–89.

  Non-Oxidative Alcohol Metabolism
- 21. Kiviniemi, M.T.; Orom, H.; Hay, J.L.; Waters, E.A. Limitations in American adults' awareness of Fatty Acid Ethyl Ester (FAEE) and beliefs about alcohol as a risk factor for cancer. Prev. Med. Rep. 2021, 23, 101433. Phosphatidyl Ethanol Keratin Matrices
- 22. Petticrew M.; Hessari, N.M.; Knai, C.; Weiderpass, E. How alcohol industry organisations mislead the public about alcohol and cancer. Drug Alcohol Rev. 2018, 37, 293–303.
- Ethyl Sulfate (EtS) Urine 23. Maso, L.D.; Torelli, N.; Biancotto, E.; Di Maso, M.; Gini, A.; Franchin, G.; Levi, F.; La Vecchia, C.; FigSter 1. in A. the; IPel, escharbor combined effects of tabacconsmoking in the Irisk of honoxidated and was k alongers: An ananalosis of case at control studies lesing Atiel, improsphalos plintano, delisy glue turonide (Eldermind ethyl sulfate 385). 393.
- 24. Hashibe, M.; Brennan, P.; Benhamou, S.; Castellsagué, X.; Chen, C.; Curado, M.P.; Dal Maso, L.; Daudt, A.W.; Fabianova, E.; Wünsch-Filho, V.; et al. Alcohol Drinking in Never Users of Tobacco, Cigarette Smoking in Never Drinkers, and the Risk of Head and Neck Cancer: Pooled Analysis in the International Head and Neck Cancer Epidemiology Consortium. J. Natl. Cancer Inst. 2007, 99, 777–789.
- 25. Applebaum, K.M.; Furniss, C.S.; Zeka, A.; Posner, M.R.; Smith, J.F.; Bryan, J.; Eisen, E.A.; Peters, E.S.; McClean, M.D.; Kelsey, K.T. Lack of Association of Alcohol and Tobacco with HPV16-Associated Head and Neck Cancer. J. Natl. Cancer Inst. 2007, 99, 1801–1810.
- 26. Gillison, M.L.; Chaturvedi, A.K.; Anderson, W.F.; Fakhry, C. Epidemiology of Human Papillomavirus–Positive Head and Neck Squamous Cell Carcinoma. J. Clin. Oncol. 2015, 33,

3235–3242.

- Sawabe, M.; Ito, H.; Oze, I.; Hosono, S.; Kawakita, D.; Tanaka, H.; Hasegawa, Y.; Murakami, S.; Matsuo, K. Heterogeneous impact of alcohol consumption according to treatment method on survival in head and neck cancer: A prospective study. Cancer Sci. 2016, 108, 91–100.
- Kawakita, D.; Oze, I.; Hosono, S.; Ito, H.; Watanabe, M.; Yatabe, Y.; Hasegawa, Y.; Murakami, S.; Tanaka, H.; Matsuo, K. Prognostic Value of Drinking Status and Aldehyde Dehydrogenase 2 Polymorphism in Patients with Head and Neck Squamous Cell Carcinoma. J. Epidemiol. 2016, 26, 292–299.
- 29. Praud, D.; Rota, M.; Rehm, J.; Shield, K.; Zatoński, W.; Hashibe, M.; La Vecchia, C.; Boffetta, P. Cancer incidence and mortality attributable to alcohol consumption. Int. J. Cancer 2016, 138, 1380–1387.
- Teckie, S.; Wotman, M.; Marziliano, A.; Orner, D.; Yi, J.; Mulvany, C.; Ghaly, M.; Parashar, B.; Diefenbach, M.A. Patterns of alcohol use among early head and neck cancer survivors: A crosssectional survey study using the alcohol use disorders identification test (AUDIT). Oral Oncol. 2021, 119, 105328.
- 31. Koo, K.; Harris, R.; Wiesenfeld, D.; Iseli, T.A. A role for panendoscopy? Second primary tumour in early stage squamous cell carcinoma of the oral tongue. J. Laryngol. Otol. 2015, 129, S27–S31.
- Metzger, K.; Horn, D.; Pfeiffer, T.; Moratin, J.; Kansy, K.; Ristow, O.; Engel, M.; Hoffmann, J.; Freier, K.; Schaible, A.; et al. Is panendoscopy a necessary staging procedure in patients with lacking risk factors and oral squamous cell carcinoma? J. Cranio-Maxillofac. Surg. 2019, 47, 1968–1972.
- Koerdt, S.; Raguse, J.-D.; Neumann, F.; Beck-Broichsitter, B.; Kreutzer, K.; Neumann, K.; Heiland, M.; Doll, C. Value of Panendoscopy in the Identification of Synchronous Malignancies in Patients Suffering from Oral Squamous Cell Carcinoma Without Clinical Signs of a Second Primary Tumor. Anticancer. Res. 2021, 41, 2039–2044.
- Dittberner, A.; Ziadat, R.; Hoffmann, F.; Pertzborn, D.; Gassler, N.; Guntinas-Lichius, O. Fluorescein-Guided Panendoscopy for Head and Neck Cancer Using Handheld Probe-Based Confocal Laser Endomicroscopy: A Pilot Study. Front. Oncol. 2021, 11, 2186.
- 35. Sheppard, S.C.; Borner, U.; Wartenberg, M.; Giger, R.; Nisa, L. Diagnostic use of fine-needle aspiration cytology and core-needle biopsy in head and neck sarcomas. Head Neck 2021, 43, 1939–1948.
- 36. Schmidt, H.; Kulasinghe, A.; Kenny, L.; Punyadeera, C. The development of a liquid biopsy for head and neck cancers. Oral Oncol. 2016, 61, 8–11.
- 37. Economopoulou, P.; Kotsantis, I.; Kyrodimos, E.; Lianidou, E.; Psyrri, A. Liquid biopsy: An emerging prognostic and predictive tool in Head and Neck Squamous Cell Carcinoma (HNSCC).

Focus on Circulating Tumor Cells (CTCs). Oral Oncol. 2017, 74, 83-89.

- Payne, K.; Spruce, R.; Beggs, A.; Sharma, N.; Kong, A.; Martin, T.; Parmar, S.; Praveen, P.; Nankivell, P.; Mehanna, H. Circulating tumor DNA as a biomarker and liquid biopsy in head and neck squamous cell carcinoma. Head Neck 2018, 40, 1598–1604.
- 39. Marcus, C.; Sheikhbahaei, S.; Shivamurthy, V.K.N.; Avey, G.; Subramaniam, R.M. PET Imaging for Head and Neck Cancers. Radiol. Clin. N. Am. 2021, 59, 773–788.
- 40. Gogna, S.; Kashyap, S.; Gupta, N. Neck Cancer Resection and Dissection; StatPearls Publishing: Treasure Island, FL, USA, 2021.
- 41. Pharaon, R.R.; Xing, Y.; Agulnik, M.; Villaflor, V.M. The Role of Immunotherapy to Overcome Resistance in Viral-Associated Head and Neck Cancer. Front. Oncol. 2021, 11, 649963.
- Cripps, C.; Winquist, E.; Devries, M.C.; Stys–Norman, D.; Gilbert, R.; the Head and Neck Cancer Disease Site Group. Epidermal Growth Factor Receptor Targeted Therapy in Stages III and IV Head and Neck Cancer. Curr. Oncol. 2010, 17, 37–48.
- 43. Kaidar-Person, O.; Gil, Z.; Billan, S. Precision medicine in head and neck cancer. Drug Resist. Updat. 2018, 40, 13–16.
- 44. Choi, J.S.; Sansoni, E.R.; Lovin, B.D.; Lindquist, N.R.; Phan, J.; Mayo, L.L.; Ferrarotto, R.; Su, S. Abscopal Effect Following Immunotherapy and Combined Stereotactic Body Radiation Therapy in Recurrent Metastatic Head and Neck Squamous Cell Carcinoma: A Report of Two Cases and Literature Review. Ann. Otol. Rhinol. Laryngol. 2019, 129, 517–522.
- 45. Hui, C.; Chau, B.; Gan, G.; Stokes, W.; Karam, S.D.; Amini, A. Overcoming Resistance to Immunotherapy in Head and Neck Cancer Using Radiation: A Review. Front. Oncol. 2021, 11, 2619.
- 46. De Oliveira, T.B.; Braun, A.C.; Nicolau, U.R.; Abdallah, E.A.; Alves, V.D.S.; de Jesus, V.H.F.; Calsavara, V.F.; Kowaslki, L.P.; Chinen, L.T.D. Prognostic impact and potential predictive role of baseline circulating tumor cells in locally advanced head and neck squamous cell carcinoma. Oral Oncol. 2021, 121, 105480.
- 47. Datta, M.; Laronde, D.; Palcic, B.; Guillaud, M. The role of DNA image cytometry in screening oral potentially malignant lesions using brushings: A systematic review. Oral Oncol. 2019, 96, 51–59.
- Datta, M.; Laronde, D.M.; Rosin, M.P.; Zhang, L.; Chan, B.; Guillaud, M. Predicting Progression of Low-Grade Oral Dysplasia Using Brushing-Based DNA Ploidy and Chromatin Organization Analysis. Cancer Prev. Res. 2021, 14, 1111–1118.
- 49. Velleuer, E.; Dietrich, R.; Pomjanski, N.; de Santana Almeida Araujo, I.K.; Silva de Araujo, B.E.; Sroka, I.; Biesterfeld, S.; Bocking, A.; Schramm, M. Diagnostic accuracy of brush biopsy–based

cytology for the early detection of oral cancer and precursors in Fanconi anemia. Cancer Cytopathol. 2020, 128, 403–413.

- 50. Vogel, E.W.; Nivard, M.J. The subtlety of alkylating agents in reactions with biological macromolecules. Mutat. Res. Mol. Mech. Mutagen. 1994, 305, 13–32.
- 51. Burtness, B.; Bourhis, J.P.; Vermorken, J.B.; Harrington, K.J.; Cohen, E.E.W. Afatinib versus placebo as adjuvant therapy after chemoradiation in a double-blind, phase III study (LUX-Head & Neck 2) in patients with primary unresected, clinically intermediate-to-high-risk head and neck cancer: Study protocol for a randomized controlled trial. Trials 2014, 15, 469.
- Zech, H.B.; Moeckelmann, N.; Böttcher, A.; Muenscher, A.; Binder, M.; Vettorazzi, E.; Bokemeyer, C.; Schafhausen, P.; Betz, C.S.; Busch, C.-J. Phase III study of nivolumab alone or combined with ipilimumab as immunotherapy versus standard of care in resectable head and neck squamous cell carcinoma. Futur. Oncol. 2020, 16, 3035–3043.
- 53. Irshad, R.; Haider, G.; Hashmi, M.; Hassan, A. Efficacy of Gefitinib and Methorexate in Patients with Advanced Stage and Recurrent Head and Neck Cancer. Cureus 2021, 13, e15451.
- Vermorken, J.B.; Mesia, R.; Rivera, F.; Remenar, E.; Kawecki, A.; Rottey, S.; Erfan, J.; Zabolotnyy, D.; Kienzer, H.-R.; Cupissol, D.; et al. Platinum-Based Chemotherapy plus Cetuximab in Head and Neck Cancer. N. Engl. J. Med. 2008, 359, 1116–1127.
- 55. Specenier, P.; Vermorken, J.B. Optimizing treatments for recurrent or metastatic head and neck squamous cell carcinoma. Expert Rev. Anticancer Ther. 2018, 18, 901–915.
- 56. Patil, V.M.; Noronha, V.; Joshi, A.; Abhyankar, A.; Menon, N.; Dhumal, S.; Prabhash, K. Beyond conventional chemotherapy, targeted therapy and immunotherapy in squamous cell cancer of the oral cavity. Oral Oncol. 2020, 105, 104673.
- 57. Lau, A.; Yang, W.; Li, K.-Y.; Su, Y.-X. Systemic Therapy in Recurrent or Metastatic Head and Neck Squamous Cell Carcinoma- A Systematic Review and Meta-Analysis. Crit. Rev. Oncol. 2020, 153, 102984.
- 58. Musshoff, F. Chromatographic methods for the determination of markers of chronic and acute alcohol consumption. J. Chromatogr. B 2002, 781, 457–480.
- 59. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Alcohol consumption and ethyl carbamate. IARC Monogr. Eval. Carcinog. Risks Hum. 2010, 96, 3–1383.
- 60. Sharpe, P.C. Biochemical detection and monitoring of alcohol abuse and abstinence. Ann. Clin. Biochem. Int. J. Lab. Med. 2001, 38, 652–664.
- Laposata, M. Assessment of Ethanol Intake: Current Tests and New Assays on the Horizon. Am. J. Clin. Pathol. 1999, 112, 443–450.

- Ferraguti, G.; Ciolli, P.; Carito, V.; Battagliese, G.; Mancinelli, R.; Ciafrè, S.; Tirassa, P.; Ciccarelli, R.; Cipriani, A.; Messina, M.P.; et al. Ethylglucuronide in the urine as a marker of alcohol consumption during pregnancy: Comparison with four alcohol screening questionnaires. Toxicol. Lett. 2017, 275, 49–56.
- Pragst, F.; Yegles, M. Determination of Fatty Acid Ethyl Esters (FAEE) and Ethyl Glucuronide (EtG) in Hair: A Promising Way for Retrospective Detection of Alcohol Abuse During Pregnancy? Ther. Drug Monit. 2008, 30, 255–263.
- 64. Yegles, M.; Labarthe, A.; Auwärter, V.; Hartwig, S.; Vater, H.; Wennig, R.; Pragst, F. Comparison of ethyl glucuronide and fatty acid ethyl ester concentrations in hair of alcoholics, social drinkers and teetotallers. Forensic Sci. Int. 2004, 145, 167–173.
- Wurst, F.M.; Alexson, S.; Wolfersdorf, M.; Bechtel, G.; Forster, S.; Alling, C.; Aradóttir, S.; Jachau, K.; Huber, P.; Allen, J.P.; et al. Concentration of fatty acid ethyl esters in hair of alcoholics: Comparison to other biological state markers and self reported-ethanol intake. Alcohol Alcohol. 2004, 39, 33–38.
- 66. Ceci, F.M.; Fiore, M.; Agostinelli, E.; Tahara, T.; Greco, A.; Ralli, M.; Polimeni, A.; Lucarelli, M.; Colletti, R.; Angeloni, A.; et al. Urinary ethyl glucuronide for the assessment of alcohol consumption during pregnancy: Comparison between biochemical data and screening questionnaires. Curr. Med. Chem. 2021, 28, 1.
- 67. Budhwani, H.; Dinaj, V.; Jacques-Tiura, A.J.; Pennar, A.L.; Naar, S. Feasibility of Ethyl Glucuronide Nail Testing Biomarker for Alcohol Use Among Youth Living with HIV. J. Adolesc. Health 2021, 69, 346–348.
- Cappelle, D.; Neels, H.; De Keukeleire, S.; Fransen, E.; Dom, G.; Vermassen, A.; Covaci, A.; Crunelle, C.L.; van Nuijs, A.L. Ethyl glucuronide in keratinous matrices as biomarker of alcohol use: A correlation study between hair and nails. Forensic Sci. Int. 2017, 279, 187–191.
- Fosen, J.T.; Morini, L.; Sempio, C.; Giarratana, N.; Enger, A.; Mørland, J.; Høiseth, G. Ethyl Glucuronide Elimination Kinetics in Fingernails and Comparison to Levels in Hair. Alcohol Alcohol. 2017, 52, 580–586.
- 70. Bogstrand, S.T.; Høiseth, G.; Rossow, I.; Normann, P.T.; Ekeberg, Ø. Prevalence of Ethyl Glucuronide and Ethyl Sulphate Among Patients Injured When Driving or at Work. Alcohol Alcohol. 2014, 50, 68–73.
- Dengiz, H.; Daglioglu, N.; Goren, I.E. Assessment of recent alcohol consumption by detecting ethyl glucuronide and ethyl sulphate level among traffic accident patients. Traffic Inj. Prev. 2020, 21, 371–374.
- 72. Skipper, G.E.; Weinmann, W.; Thierauf, A.; Schaefer, P.; Wiesbeck, G.; Allen, J.P.; Miller, M.; Wurst, F.M. Ethyl glucuronide: A biomarker to identify alcohol use by health professionals

recovering from substance use disorders. Alcohol Alcohol. 2004, 39, 445-449.

73. Liu, H.; Dai, M.; Guan, H.; Gao, X.; Zhou, Y.; Sun, X.; Zhou, J.; Hu, X.; Li, X.; Song, Y.; et al. Preoperative Prognostic Nutritional Index Value is Related to Postoperative Delirium in Elderly Patients After Noncardiac Surgery: A Retrospective Cohort Study. Health Policy 2021, 14, 1–8.

Retrieved from https://encyclopedia.pub/entry/history/show/44049