Review on low-tech anesthesia

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I Situated knowledge

In this section, I explain briefly who I am to provide context to readers and information about the construction of my situated knowledge (Haraway, 1988).

I am a non-binary middle-class white French person usually perceived as male. Most of the information I assimilated over the years and my points of view on the world are therefore coming from a position of privilege, and restricted almost exclusively to what is considered valid knowledge in the Global North. My work is more likely to be considered neutral, my way of thinking and expressing myself are inherited from a falsely-considered superior civilization, and are derived from an education where I accessed resources many do not have. My intelligence and position in society are never questioned because of who I am, and I am less socially pushed towards self-reflection and modesty.

I am a far-left politically-engaged activist for social and climate justice, democracy and equality, universal rights and freedoms, and direct democracy. I am an advocate for economic degrowth not only as a necessity to anticipate the crises to come, but as an essential movement towards the achievement of a desirable future for humanity. Thus, the low-tech movement is of special interest to me since, in the definition proposed by the team I worked with, it aims at building knowledge for the creation of sustainable, ethical and desirable socio-technical systems.

I am neither a healthcare professional, a historian, an economist, or an anthropologist. I write this article during my internship on the topic of degrowth in research. My studies were not on medicine, but mostly in the field of computer science in which I completed a PhD. I studied some university low-level physics and chemistry, and nothing on medicine. Thus, my knowledge of anesthesia and medicine in general is based on articles and books I have read out of personal interest, and in the context of my internship.

II Low-tech

The concept of low-tech used in this work is defined in (Carrey and Lachaize, 2020; Carrey, Lachaize and Carbou, 2021): a technology is low-tech if it is a base element of a sustainable, equitable, and convivial (Illich, 1973) society. A society is sustainable if human population, technologies used, and the energy and workload necessary to maintain the technical system remain mostly the same during several millennia. A society is equitable if it is not based on any human exploitation and if the socio-technical system is accessible to all. A society is convivial if individuals have control over the ways they use to satisfy their needs.

Therefore, a solution cannot be evaluated as low-tech on its own, but as a technical block of a sustainable, equitable, and convivial society. A technical block can be built on top of other technical blocks which are required for the technical block to be built or to function properly, and other technical blocks can be built on top of the technical block. For instance, a wooden plank is a technical block that requires technical blocks such as an axe to obtain wood, and a table is a technical block that requires a wooden plank. From this point forward, the technical blocks required by another technical block will be called the dependencies of that technical block.

i Low-tech grid

With that said, it is possible and useful with rough approximations to have an idea if a solution has a chance to fit in a low-tech world.

To that end, with my colleague and friend Manue Girard, we created a non-exhaustive list of quantitative or qualitative criteria which we linked to either sustainability, equity, or conviviality. The whole grid of criteria is in Table #LowTechGrid|table. Again, this tool cannot be used to evaluate precisely if a solution can be low-tech since that will depend on its use in a specific low-tech environment, the grid is only meant to give an idea of the potential of the solution to fit in low-tech environments. The authors of the grid acknowledge that it is far from perfect, and criteria could be added, removed, or modified to obtain improved versions.

To simplify the assessment process, each criteria of the grid put a solution in one of three classes. Each of these three classes has a symbol and a color, with red square ■ for probably unsuited for a low-tech world, yellow diamond ♦ for likely unsuited, and green circle ● for probably suited.

For a given technical block, it would be possible to evaluate the quantities of resources required to build and use one instance. However, this is not helpful since the sustainability of the use of a technical block heavily depends on parameters of the organization of the socio-technical system. For example, if there is one car for every community, the amount of resources would be much lower than one car per person. It also would make no sense to apply estimations on the entire world since resources used for a given technical block could be very different depending on the location of use. For example, trees are very different depending on the location on Earth, so wooden objects are also very different. Some technical blocks, such as natural rubber, are even inaccessible in many locations because of this fact. Distances are also a problem since they obviously depend on where the community is situated. For example, communities not far from volcanoes have access to sulfur that will be more difficult to find otherwise. Hence the need to make certain systemic hypotheses when using the grid, for some criteria the evaluation only make sense in a systemic context. The common hypotheses to use the grid are the size of the community, its spatial location, and the date of analysis. The size allows us to know the scale of needs of the community for a technical block, and the location and date give us the availability and distance to resources.

As said before, a technical block is built on top of other technical blocks called its dependencies. When using the grid, for each criteria, the class of a technical block should be the worst class in the set composed of the classes of its dependencies for that criteria and the class for the technical block alone. For example, if sulfuric acid is red in the distance criteria because sulfur is far from the location of the community, then any block building from sulfuric acid should be red for the distance criteria. Therefore, for an analysis of a technical block, it is necessary to consider what to do with those dependencies. There are two main motivations for those analyses. The first motivation is to evaluate the chance of a given technical block to compromise an aspirant low-tech socio-technical system. In this case, hypotheses should be added to the analysis that the dependencies pass all the criteria of the grid. These analyses will be called G_0 in the rest of the document. The second motivation is to have an idea of the evaluation of a technical block in a socio-technical system, in that case either the dependencies have been evaluated with similar systemic hypotheses and the results of the evaluation can be reused, or some hypotheses should be applied on the dependencies.

These analyses will be called G in the rest of the document. Examples of such analyses can be found in the rest of this paper.

A Sustainability (∞)

In this grid, sustainability of a technical block is defined by the accessibility of resources, the amount of external environmental impacts, the amount of resources used, the necessity of the technical block for the communities, and the period when this technical block could have been implemented.

In the distance criteria, the distances considered acceptable for the gathering of resources required for a technology are based on the distance reachable with a technology such as a cargo bike in a reasonable amount of time, for instance the 100 kilometers limit represents roughly a two-day trip. Technologies such as planes, cars, or trains are excluded for reasons that will be detailed later. For a resource the distance considered should be the one of the closest source that can meet the need of the technical block. When for a same technical block there are resources with different classes of distance for this criteria, the chosen class is the worst class among these resources.

The land system change criteria validates technical blocks that do not induce land change or restore natural habitats. It partially rejects the replacement of artificialized land with agriculture, and structures made of local resources such as wood, stone, or earth. Thus, de-artificializing to grow crops is only partially rejected, and building solar ovens or wooden houses in the forest are not completely rejected either. Any other land change including roads, deforestation, or artificialization are rejected by this criteria.

The pollution criteria rejects any change in the environment that goes beyond manual organic agriculture. So heating a river, adding novel entities in a forest, releasing significant quantities of carbon dioxide in the atmosphere are all rejected. This criteria includes the pollution induced by the end of life of the technical block.

The two resources criteria evaluate the amount of resources required by the technical blocks, which is essential to approximate if a technical block could fit in a low-tech world.

In the renewable resources criteria, the chosen metric is a comparison between the amount of resources used to their rate of renewability. For instance, if a community has access to 100 trees and needs 10 of them every 10 years to build houses, but the trees have to grow for 100 years. An hypothesis is made here that the accessibility of resources correlates with their available quantity.

In the non-renewable resources criteria, since by definition non-renewable resource do not regenerate their stock, the criteria instead compares the rate of consumption of the resource to the local stock to verify that the resource will not be depleted in thousands of years to respect the sustainable criteria for a low-tech society. For this criteria, ideally the technical block should not require any non-renewable resource. However, it is reasonable to think that socio-technical systems will require some of these resources given their unique properties. Stone or some metals like copper for instance are present on Earth in very large stocks and could be used in reasonable quantities. A limit of a hundred thousand years minimum for the total exhaustion of the resource allows for this reasonable use of some non-renewable resources. This limit refers to the time between two ice ages, during which the extreme climate conditions make it difficult to imagine a sustainable socio-

technical system. Thus, this limit of hundred thousand years minimum is taken as an ideal for a low-tech technical block. As for the thousand years limit this choice means that the criteria will reject strongly most technologies that are used today and which depend on oil, gas, and coal.

The necessity criteria evaluates the usefulness of a technical block. Essential needs are inspired by the 14 needs established by Virginia Henderson, out of them, the ones considered in this study are, breathe pure air, drink pure water and eat quality food, get rid of body waste such as urine and feces, exercise, sleep, getting dressed and undressed, maintain body temperature, basic hygiene, being able to ensure one's physical and mental safety, socialize, act in accordance with one's values and beliefs, engage in meaningful, stimulating and fulfilling activities, entertain oneself, and learn. Technical blocks that do not directly fulfill essential needs could be jewelries, nail polish, candies, roller coaster. Harmful technical blocks would include weapons, drugs including alcohol, tobacco. This aims to open debates in the communities on the usefulness of technical blocks. For this study, the authors choose according to their point of view and explicitly develop their choices.

For the period criteria, the approximation used is that if a technology could have been manufactured before the Global North Industrial Revolution, then it is suited for a society that functions outside of the economic growth paradigm.

B Equity (=)

Equity of a technical block is defined by the quality and amount of human work, the amount of animal work and the relationship between humans and other animals, and inclusivity.

The human work criteria measures the safety, the meaningfulness, and the fulfillment of work. Capitalism is inherently incompatible with the notion of an equitable society since it is based on the human exploitation of workers by others who own the means of production. Therefore, the criteria does not measure parameters such as salary or working hours, which are characteristic of the capitalistic system.

The animal work criteria measures qualitatively the level of harmony between humans and other animals. Harmony in the anti-speciesism sense, where animals are granted rights and the human species is not considered superior to others. Therefore, the criteria accepts humans using sheep to eat grass under fruit trees since it does not affect negatively their life conditions, however forcing horses to pull heavy carriages is not accepted by the criteria. As a middle ground, if cows are used to pull carts for agriculture but with limited hours of work and weight to move as well as appropriate care, this would be insufficient to fully meet this criteria.

The inclusivity criteria rejects technical blocks for which only a few individuals are able to use them. Able is used here not as a normative term but as a requirement for technical blocks to be modular, simple, flexible. Technical blocks should adapt to the diversity of people, not the other way around. Stairs make places inaccessible to a big part of the population. Many things like technical gear are tailored to suit medium-size men. Some heavy tools cannot be used by people who cannot carry weight. Bicycles and cars are difficult to use for people with some neurodevelopmental disorders, and unusable for visually impaired people and so are traffic lights not equipped with audible signals. Not every single individual needs to be able to use the technical block to pass the criteria, but it should at least be usable by someone in a close group (family, close

friends, etc.). A technical block that can be used only by a few in every community, for instance a very heavy tool, only partially passes. Note that this criteria only evaluates the technical aspect of the final solution, it does not take into account the fact that some communities may not be able to have access to the solution because the resources required to manufacture it are not available.

C Conviviality (o)

Conviviality of a technical block is defined by the accessibility (in the sense of appropriation by a large number of people or communities) of manufacturing, use, and repairing, and the practicality of use.

The manufacturing criteria measures the accessibility of the making process. A nuclear plant can only be made by a very large group of specialists in construction, nuclear physics, electricity, etc., while making nice furniture requires one or a few specialists with knowledge of wood joinery techniques. The difference between the two lies in the amount and variety of specialized knowledge required which is much higher for the nuclear plant. A technique that can be made by a majority of people leans towards conviviality.

The use criteria measures the time necessary to learn how to use the technical block. If a technical block requires months of learning to use effectively, then it likely means that only specialists will use it, decreasing the autonomy of the rest of the community. For example, a pair of scissors take almost no time to learn how to use, while a car requires a long time to learn how to drive, to do so safely, to learn the road signs, etc.

The practicality of use evaluates the ease of use independently of the amount of time required to learn how to use the solution. Acceptability of the solution is a crucial part of its conviviality and thus is important for the low-tech analysis. In this grid, as an approximation, acceptability is partially measured through this criteria of practicality. If a solution is dependent on factors out of the control of the user, such as the weather for a solar oven, then this criteria rejects it because then the solution is not very practical and thus less likely to be accepted and used. If there is a periodic mental load, such as a tool that requires to press a lever every few hours, then this criteria partially rejects the solution, since the constraints are in the control of the user but are still restrictive enough to risk rejection of the solution.

The repairing / maintenance criteria passes if most people can repair the technical block using simple tools and basic knowledge. No possibility to repair implies the use of a lot of resources to re-manufacture. Complexity of repair implies an increased chance of loss of autonomy and lack in resilience.

	Criteria	Quantification or qualification value	Level of validation (■, ♦, ●)
Sustainability (∞)	Distance between the point-of-use and localization of the resources	Distance in kilometers (km)	■ 500 km < d ♦ 100 km < d ≤ 500 km ● d ≤ 100 km
	Land system change	Type of land change	■ Any other type of land change ♦ Agriculture replacing artificialized land, structures made of local wood, stone, earth ● None or restoration, harmony with natural habitats
	Pollution	Soil, air, water pollution N, P, CFCs, CO2 emission Any physical or chemical change (temperature, pH, concentration in nitrogen, etc.)	■ Introduction of novel entities or other significant impact on the environment ♦ Pollution that do not affect the environment more than manual organic agriculture ● Pollution that do not affect the environment more than human physical activity
	Primary renewable resource	Ratio used compared to the accessible renewed stock	■ r > 5% ♦ 1% < r ≤ 5% ● r ≤ 1%
	Primary non-renewable resource	Period after which use exhausts the accessible existing stock	■ t < 1,000 years ♦ 1,000 years ≤ t < 100,000 years ● 100,000 years ≤ t
	Necessity	Level of importance for the community or the individual	■ Harmful ♦ Non-essential need ● Essential need
	Period when it could have been manufactured in Europe	Year	■ After the Great Acceleration (~1945) ♦ After the start of the Global North Industrial Revolution (~1760) ● Before the Global North Industrial Revolution

Equity (=)	Human work	Dangerous / alienation / drudgery	■ Risks of deadly or serious injuries, repetitive tasks, meaningless work ♦ Moderate risks for health, meaningful but uninteresting work ● Safe, meaningful, fulfilling work
	Animal work	Devastation / exhaustion / symbiosis	■ Exploitation of animals, human superiority ♦ Moderate exploitation of animals, human superiority but some animal rights ● No loss of animal life quality, harmony with animals
	Inclusivity	Amount of individuals which could be able to use it	■ Only some individuals ♦ Every community ● Every group of individuals inside every community
Conviviality (o)	Manufacturing	Number of specialists required	■ A large group of specialists is necessary to make it ♦ A few specialists can make it ● Almost everyone can make it
	Complexity of use	Time to learn how to use	■ 10 days < t ♦ 1 day < t ≤ 10 days ● t ≤ 1 day
	Practicality of use	User control and mental load	■ Efficient use depends on factors that cannot be controlled ♦ Efficient use depends on periodic mental load but is fully under user control ● Use does not imply mental load and is fully under user control
	Repairing / maintenance	Number of specialists required to repair it	■ Cannot be repaired ♦ Can only be repaired by specialists or with complex tools ● Can be repaired with basic tools and little operational knowledge and skills, clear guides are accessible

Table 1: Low-tech grid for evaluation of a technical block

III Healthcare

This section aims to provide a critical viewpoint on our current healthcare system based on the analyses of different sources. This explains our particular interest in the evolution of care towards more low-tech solutions.

i Healthcare today

Health expenditures have reached tremendous levels in some rich countries with little benefit on life expectancy or health service coverage (see Figure #HealthDependingOnSpendingPerCapita| graphic), whereas in low-income countries trained physicians and essential resources are scarce (Mohamed and Garba, 2026). Inappropriate laboratory testing is commonplace, leading to increased likelihood of false-positive results and thus incorrect diagnoses, misuse of resources which could be used for other patients or not at all, unnecessary blood draws and longer hospital stays, and degradation of care in general (Zhi *et al.*, 2013). Iatrogenesis, which includes all ill effects as a consequence of medical intervention, is the fifth leading cause of death in the world (Peer and Shabir, 2018). Adverse reactions to medicine, infections contracted during care, and generally errors from medical professionals are common and avoidable with better education of doctors on safe practices, reduction of corruption by pharmaceutical companies, and intervention at the state and international levels to ensure a safer environment.

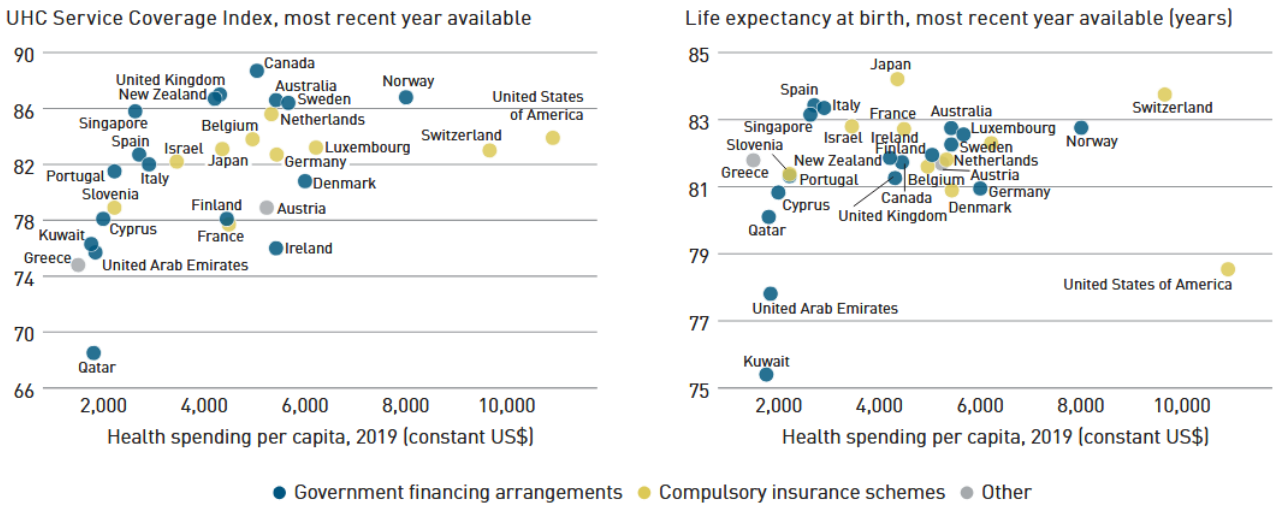


Figure 1: Health service coverage and life expectancy depending on the spending per capita in 29 high income countries

Source: (WHO, 2021)

It is crucial to debate and decide democratically on the future of our healthcare system. Breaking the taboo on healthcare is not an easy task, ethical dilemmas will only be answered with sincere, profound, inclusive discussions which will take time (Carrey, Lachaize and Carbou, 2021). As for many other aspects of society in need of radical change, this discussion must happen as soon as possible. As the window of opportunity to act narrows (Calvin *et al.*, 2023), every delay reduces the leeway after finally deciding to take drastic action.

Modern societies rely on healthcare systems to help people broken by dangerous, excessive, and stressful work, by social norms, inequality, misery, anxiety. Degrowth is a solution to handle these

issues directly instead of aiming at their symptoms (Missoni, 2015; Borowy and Aillon, 2017; Kronenberg *et al.*, 2024). (Parrique, 2022) shows that economic growth goes against social progress and harms the environment instead of meeting the needs of the population.

The example of Cuba, which had to adapt to a forced recession in the 1990's after the collapse of the USSR, shows that a satisfactory healthcare system can be achieved in a deflating economy with political planning (Borowy, 2013). To compensate for the economic crisis and the US embargo which caused a major shortage in essential provisions such as drugs and medical equipment, but also electricity and even water, political prioritization and community-based health services allowed the country to keep a very efficient medical system. The number of doctors rose by 76% between 1990 and 2003, and the number of care facilities increased significantly as well. Additionally, the health care system in Cuba relied on many volunteer community workers.

While financial crises are associated with rising unemployment, social instability, the rise of suicides, and excess infant mortality, evidence also shows that they can paradoxically generate favorable health outcomes even without rigorous planning (De Vogli and Owusu, 2015).

The directions taken by research is a matter of politics, and medicine is no exception. For instance, research in endometriosis remains critically underfunded despite the severity of its symptoms and the high estimated number of people affected, 1 in 10 people with menstrual cycles according to the World Health Organization (Viganò, Casalechi and Dolmans, 2024).

Literature is not lacking on the environmental impact of healthcare and on ways to reduce it (Lenzen *et al.*, 2020; Seppänen and Or, 2023, 2025; Elnenaei, Thoni and Mattman, 2025). But most recommendations only target the reduction of carbon emissions, sometimes the reduction of plastic waste or water pollution. Some publications discuss the necessity of systemic change (Seppänen and Or, 2023), but they only scratch the surface of the planning and social debates that would be required to achieve a resilient healthcare system.

ii Life expectancy

Life expectancy at birth is a statistical measure of the average remaining years of life of an individual after their birth. It is commonly used to evaluate the health of a population in a given time period. Estimates on human longevity in ancient times are not very reliable. Life expectancy before the 18th century are estimated based on data gleaned from tombstone inscriptions, genealogical records, and skeletal remains, and these estimations are based on many assumptions which are debatable (Wilmoth, 2000). Historians evaluate life expectancy before the 19th century to have stayed roughly between 20 and 40 years. Although some evidence suggests that hunter-gatherers could have lived longer, it seems that their life expectancy at birth was in the same range (Gurven and Kaplan, 2007). Nowadays, the estimated world average is around 73 years with an approximate range per country of 50 to 85 (WHO, 2025).

Although life expectancy is a useful metric, it has its limits. Life expectancy ignores many important factors such as quality of life or inequality. Different measures attempt to solve this, for instance healthy life expectancy (HALE) which estimates the average years of life of an individual without disability or disease, or the disability-adjusted life year (DALY) which measures the impact of diseases and disabilities on productivity and health. However, these indicators are also far from

perfect and have been heavily criticized by experts from various disciplines, in particular on their many blind spots and on their blatant ableism (Parks, 2014; Lundberg and Chen, 2024). There are a few other indicators that have been developed in the 21st century that are not explored in detail in this work, but they all have limits, either because they do not measure important dimensions of well-being, or because their attempts give inconsistent results due in part to the highly subjective and culture-based nature of what they attempt to estimate such as happiness. Thus, in this section, classic life expectancy is considered for the discussion on what played a role in the variations of health in human population over the centuries.

A major factor of low life expectancy used to be child mortality (OECD, 2014). Young children are particularly vulnerable, especially during their first month of life. In 2024, neonatal deaths represent almost half of deaths under 5 years (UN IGME, 2026). Premature births, birth asphyxia and trauma, and infections are the leading causes of deaths in the first month of life. When child mortality is reduced, the effects on life expectancy are much stronger than the impact of delaying deaths of adults, since children that do make it through their risky first years are likely to live long lives. According to the The United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), estimates of child mortality under 5 years worldwide have fallen from 93 per 1000 births in 1990 to 37 in 2024, and from 1949 to 2024 these estimates have been divided by 6 in Cameroon, by 8 in New Zealand, by 14 in France. Child mortality remains relatively high and with important disparities. In 2024, an estimated 4.9 million children under the age of 5 years died worldwide, and in low-income countries the mortality rate is nearly 14 times higher than in high-income countries, and the vast majority of countries with the highest rate are located in sub-Saharan Africa (UN IGME, 2026). At the start of the 19th century, 1 in 2 children died before reaching the end of puberty. Infant mortality used to be so high that remaining life expectancy at age 1 was greater than at birth (Wilmoth, 2000). There are many causes attributed to the huge decline of child mortality. Most of them are not related to healthcare. They include better treatment of water, better nutrition, sanitation, reduction of poverty in general (Schmertzing, 2019).

Most of the main causes of death were not solved by medicine. Wars and famines represent most of the leading mortality crises of the 20th century (Riley, 2001). The Great Influenza epidemic was mostly handled by control measures such as social distancing, quarantine, mandatory face masks, business shifts and curfews (Bootsma and Ferguson, 2007). Scarlet fever, diphtheria, whooping cough disappeared on their own due to better living conditions at the beginning of the 20th century (Illich, 1976). Nowadays, smoking is the leading preventable cause of disease and death in the United States (United States Surgeon General, 2014).

However, medicine did play a major role in the increase of life expectancy.

Vaccines eradicated or greatly weakened some of the most deadly and contagious diseases in recent human history such as smallpox, polio, measles (Kayser and Ramzan, 2021), and COVID-19 (Sibanda and Haryanto, 2024). The process of administrating a weakened or killed form of a disease to provide immunity has proven its efficiency since at least 16th century China, where variolation was practiced, which is inoculation to immunize individuals against smallpox, but those kinds of practices are possibly even older (Boylston, 2012).

In the first half of the 20th century, bacterial infections were one of the leading causes of death. One third of deaths in 1900 in the USA were caused by pneumonia, tuberculosis, diarrhea, enteritis, and

diphtheria (see Figure #Leading causes of death in the USA|graphic). Minor injuries or common illnesses could be fatal because of the inability to combat infections. Therefore, medical specialties such as surgery had a high death rate. Antibiotics are antibacterial agents that can be found naturally, although nowadays they are modified and improved in laboratories. Their first known use go back as far as 2500 years ago in China, but modern medicine discovered antibiotics such as penicillin, streptomycin and tetracycline only in the 1940-50s. Antibiotics revolutionized medicine by providing a very effective treatment against bacterial infections, drastically increasing life expectancy (Kourkouta, 2018). Some evaluate the increase of life expectancy by 23 years between the start and the end of the 20th century (Hutchings, Truman and Wilkinson, 2019). After the development of antibiotics and vaccines, the leading causes of death in rich countries became noncommunicable diseases such as heart disease, cancer, and stroke. Antiseptics such as alcohols or peroxides are antibacterial agents used to prevent infections. Sumerians more than four thousand years ago used beer and hot water to wash wounds (Eming, Krieg and Davidson, 2007). Deadly postpartum infections were common in childbirth until the end of the 19th century when the medical profession finally accepted that washing their hands with an antiseptic solution between deliveries, and the decline in death rate continued in the 20th century thanks to antibiotics.

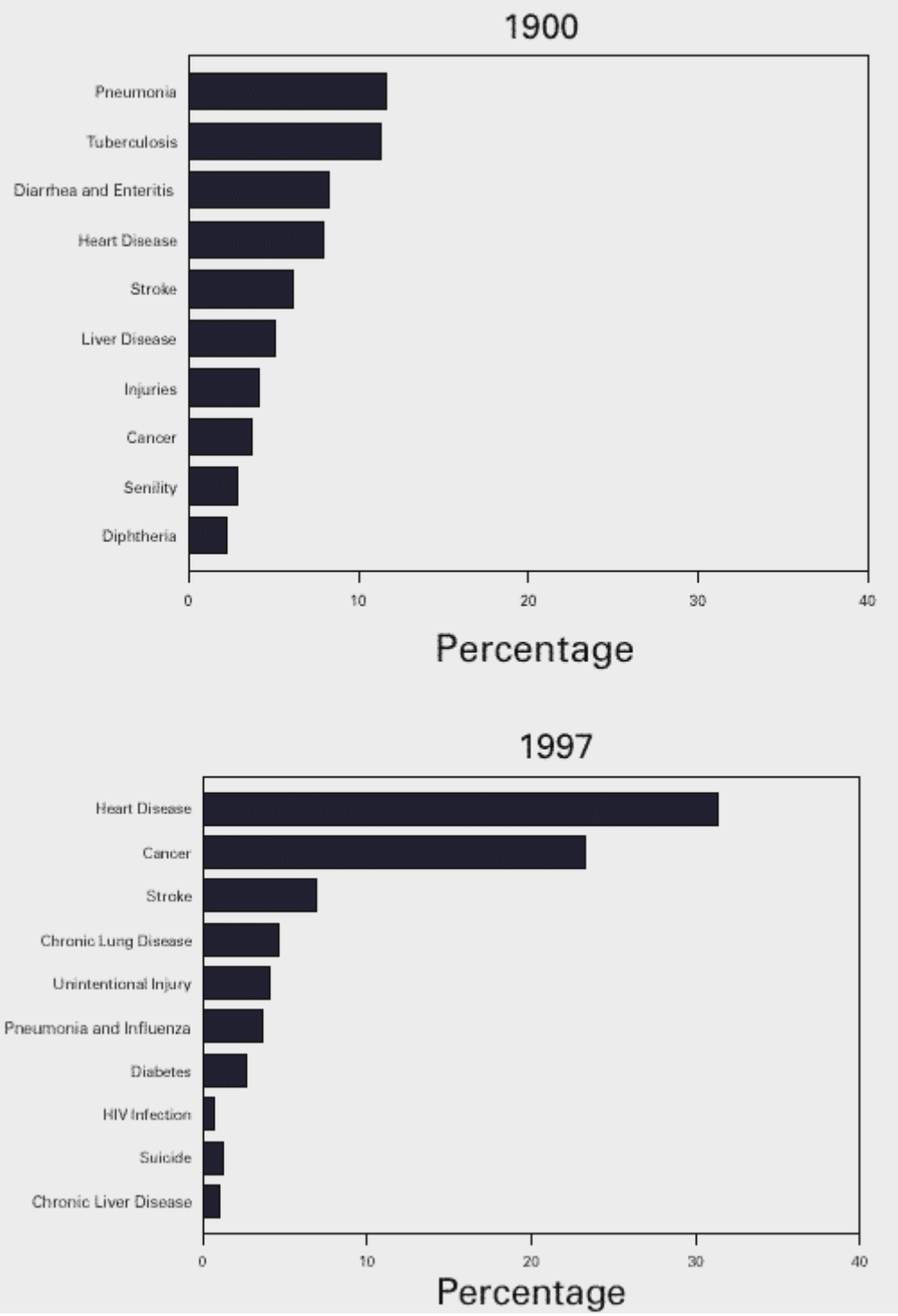


Figure 2: Top 10 leading causes of death as a percentage of all deaths in the United States of America

Source: (CDC, 1999)

HIV infections are still incurable today, making antiretroviral therapy essential to reinforce the immune system weakened by the disease. This implies the use of complex molecules that could likely not be synthesized by communities in a low-tech world.

The World Health Organization shows that cesarean sections are associated with decreases in parent and infant mortality but only in cases when it is medically justified (WHO, 2015). Cesarean

delivery rates higher than 10% are not associated with decrease of mortality rates. However, the actual rate of cesareans is much higher which gives concern to the scientific community since the procedure involves risks for both the infant and the person giving birth. In the United States, a third of births involve cesarean delivery with the rate going as high as 70% in some hospitals (Caughey *et al.*, 2014).

Although the major increase of life expectancy in recent years is mostly due to better living conditions, in particular better nutrition (Kinsella, 1992), it is undeniable that medicine played a significant role in some key aspects. However, vaccines, antibiotics, antiseptics, obstetric care, can all be produced and performed in a low-tech world, which brings the question of how much of the high-tech healthcare system in rich countries is actually necessary.

IV Anesthesia

Anesthesia refers to the medical techniques to prevent or reduce feelings of pain (analgesia) and other sensations, to induce loss of consciousness and memory, and loss of motor function in muscles. Anesthesia is mostly used to prevent pain, trauma, and unwanted and potentially dangerous movement during or following surgeries and other medical procedures (NIGMS, 2023).

There are four different types of anesthesia (Geng, 2021).

General anesthesia acts on the central nervous system and causes unconsciousness using either injected or inhaled anesthetics. General anesthesia is used for heavy surgical procedures, or more generally when it is safer and more comfortable for the person to be unconscious.

Sedation acts on the central nervous system on a lesser degree, relaxing the person instead of rendering them unconscious. It is typically used in minor surgical procedures.

Local anesthesia blocks nerves from sending pain signals to the brain in a specific part of the body. It is mainly used for treating localized pain, and for minor procedures such as dental work, skin procedures, or medical tests. Local anesthetics may be injected or applied on skin or mucous membranes.

Regional anesthesia is local anesthesia applied to a larger area by injecting a local anesthetic near a nerve cluster. For instance epidural anesthesia is commonly used for childbirth, and involves the injection of local anesthetics in the epidural space around the spinal cord.

Doctors use techniques that belong to one or several of these types of anesthesia depending on factors such as the type of medical operation, medical history, medical condition, and preference of the person, necessity of involvement of the person during the procedure. Additional products may be used, such as morphine or other opioids to control autonomic nervous system responses during surgery, or muscle relaxants to facilitate endotracheal intubation and ensure immobility.

i History of anesthetics

Attempts at diminishing pain started as early as in prehistoric times. Ancient humans used cold water and heat to provide relief. They exorcised and fought demons which were the cause of the pain, they used healing magic to banish it, priests combined medicine and prayers to combat it.

Residuals of medicine used in ancient days and writings from Mesopotamia, India, Egypt, China, and other places show that reaching unconsciousness or an altered state of consciousness was attempted by people of all epochs and all places (Cousin, 2007). They made concoctions from various fruits, herbs, plants to ease suffering, combat fatigue, or contact gods. They also attempted to find recipes to shut down pain and trauma to perform surgery.

Before the 19th century, many techniques or substances were used to attempt to manage pain in particular for surgeries. However, the majority of them such as alcohol, cannabis, opium, mandrake, or henbane either implied very high risks to patients or were ineffective depending on the product and the dosage. There are also records which pretend some products can induce sleep and analgesia in patients, but modern experiments show that their effectiveness was at best very mild, nowhere near enough for true anesthesia to occur. An example of this is the “spongia somnifera”, a sponge which absorbed a mixture of different plants usually to be held against the nose and mouth of the patient. Its various recipes in different times and places are likely attempts to use ingredients that were known to induce coma or death in a harmless way, but this could only have led to a totally ineffective product (Prioreschi, 2003). Thus general anesthesia was unachievable and surgeries, when attempted, which was rare, were a nightmare to go through (Gawande, 2012; Carrey, 2020).

Then, starting from the 19th century with the discovery of effective inhaled anesthetics such as ether and chloroform, began a search for the perfect agent, ideally something pleasant and easy to administer, that would induce anesthesia quickly and maintain it reliably, with a low recovery time, with analgesic and muscle-relaxant properties, and no adverse effects.

The following sections review some anesthetics that are interesting to study for our research, either because they are of historical importance, because they are promising candidates for low-tech anesthesia, or because they are deemed essential today.

A General anesthetics

a Tsūsensan

At the beginning of the 19th century, a Japanese surgeon named Seishu Hanaoka, studying ancient Chinese medicine, developed the formula of Tsūsensan, a mixture administered as a drink, based on several plants, and used as a general anesthetic (Ogata, 1973). The mixture included datura, angelica, aconite, crow-dipper, ligusticum striatum, ginseng, and cobra lilies.

With Tsūsensan, Hanaoka performed the first successful surgery for breast cancer under general anesthesia in 1804, and hundreds other surgeries under Tsūsensan followed in his lifetime. However the mixture took two to four hours to take effect, and was very dangerous especially even when prepared in the exact correct proportions, Hanaoka’s wife who volunteered for his experiments lost her sight. The reason for this is that the observed state of anesthesia, analgesia and hypnosis was obtained by intoxication with scopolamine, hyoscyamine, atropine, aconitine, and angelicotoxin, which could easily lead to death. Unfortunately, this experiment which was an undeniable success at the time would not continue in modern anesthesia, since ether and chloroform introduced decades later will prove to be superior in every way.

b Inhalational anesthetics

The first real general anesthetics were administered as via inhalation. This section goes through the history, advantages and drawbacks, and ways to synthesize some of the most important historical and modern inhalational anesthetics.

Nitrous oxide

Nitrous oxide, also known as laughing gas, is a chemical compound of formula N_2O. It is a colorless gas with a weak sweet odor. Nitrous oxide is one of the first general anesthetics.

The first record of synthesis of the gas goes back to 1772 by English chemist Joseph Priestley (Goerig and Schulte Am Esch, 2001). In 1799, British chemist Humphry Davy noted during experimentation with nitrous oxide a relief from tooth pain, and formulated the hypothesis that the gas could “probably be used with advantage during surgical operations”. Despite of the relative enthusiasm that followed, nitrous oxide would not be used for pain relief in surgeries for decades. It is in 1844 in America that dental surgeon Horace Wells observed the analgesic effects of nitrous oxide on an assistant during a show by Gardner Quincy Colton. The next day, Wells and Colton successfully used nitrous oxide to extract a tooth from Wells. Wells would then use nitrous oxide on several of his patients, and gave a clinical demonstration in January 1845 at the Massachusetts General Hospital. Unfortunately, this demonstration was a partial failure which lead to the disappearance of the gas for another couple of decades. In 1863, Colton gives another demonstration in New Britain, successfully removing a tooth from a woman, then another at the International Exhibition in Paris in 1867 from where popularity for nitrous oxide in dentistry would then finally rise.

With time, use of nitrous oxide was found to be the cause of cardiac arrests due to the effect of the gas which decreases the partial pressure of oxygen in the lungs causing hypoxia, that is the lack of oxygen in parts of the body. Nitrous oxide was then administrated in a mix with oxygen to reduce unwanted side effects. However, in 1936, American neuropathologist Cyril Brian Courville demonstrates that even mixed with oxygen, nitrous oxide is not viable as sole anesthetic agent, as its lack of potency forces the use of a high dose to induce anesthesia, resulting in a non-negligible number of cases of asphyxia (Courville, 1936).

Nitrous oxide is still sometimes used in anesthesia today, although it tends to disappear in modern health centers. However, it is never used as the main anesthetic agent since it cannot reliably maintain anesthesia during an entire operation due to its weak potency. Nitrous oxide is quick to take effect, and its elimination by the body is also fast. Anesthetists use a combination of nitrous oxide with oxygen to reduce the dose of more potent anesthetics which are usually more expensive and have more side effects. Additionally, studies show that the use of nitrous oxide reduces the amount of time for anesthesia to take effect with another gas, a phenomenon known as the “second gas effect” (Myles *et al.*, 2004).

As for adverse effects, nitrous oxide causes vitamin B_{12} deficiency by oxidation of the cobalt ion at the center of the vitamin, which may lead to nerve and spinal cord damage. Therefore, its use is not recommended for individuals with associated risk factors, such as the elderly and people following a vegan diet. Evidence shows that use of nitrous oxide during anesthesia increases the risk of postoperative nausea and vomiting, but it has been recently shown that the use of nitrous oxide does

not increase risks of postoperative cardiovascular diseases which was suggested in older studies (Buhre *et al.,* 2019). The use of nitrous oxide forces the inclusion of anti-hypoxic devices in anesthetic machines in particular in case of failure of oxygen delivery.

Nitrous oxide can be synthesized by the decomposition of ammonium nitrate which can be produced with ammonia and nitric acid. However, nitrous oxide is a potent ozone-depleting molecule, in fact it is the greatest ozone-depleting substance today *(Ravishankara, Daniel and Portmann, 2009),* and projections show that this fact should remain true in the rest of the 21st century. Nitrous oxide is also a potent greenhouse gas, 273 times more potent than carbon dioxide, and its emissions from human activity has led to an increase of concentration in the atmosphere of 20 percent compared to pre-industrial levels (Tian *et al.*, 2020). This man-made pollution mostly comes from agriculture, in particular because of the use of nitrogen fertilizers. Nevertheless, anesthesia is estimated to represent 1 to 3 percent of worldwide emissions of nitrous oxide. For these reasons, experts are of the opinion that nitrous oxide should be abandoned for anesthesia (Pauchard *et al.*, 2023) since the use of this agent aggravates the environmental impact with no benefit to the health of the patients, or at least that delivery circuits should be dismantled and replaced with bottles of nitrous oxide for professionals who choose to keep using it. These recommendations are currently being implemented in France (Alter, 2024).

Diethyl ether

Diethyl ether is a well-known historical inhalational anesthetic (Encyclopædia Britannica, 2026b), an organic compound of formula $C_4H_{10}O$, composed of two C_2H_5 ethyl groups linked through an oxygen atom. It is also known as ethyl ether, or ether, although ethers also refers to the general category of chemicals made of an oxygen atom connected to two organyl groups. Ether is an extremely flammable liquid (boiling point of 34.5° C). It is colorless, very volatile, with a characteristic sweet odor.

The first recorded use of ether as a general anesthetic for humans is in 1842, when the American physician Crawford Williamson Long removed a tumor from the neck of a patient who was under the effects of ether anesthesia. (Encyclopædia Britannica, 2026a). Long would not publish his findings for many years. In 1846, a Boston dentist by the name of William Thomas Green Morton experimented with ether, and performed the first public demonstration on a patient of its anesthetic properties on October 16, 1846, at the Massachusetts General Hospital. At this demonstration, Dr. John Collins Warren administered ether to a patient, then performed a surgical operation during which the patient remained unconscious (U.S. National Library of Medicine, 1896).

Ether can cause postoperative nausea and vomiting, other inhalational anesthetics also trigger those symptoms but with a possibly lower incidence. Its smell has been described as unpleasant. It is also irritating to the mucous membrane of the respiratory system, which can trigger coughing and salivation. Although it is considered a safe agent, ether can trigger tachycardia since it stimulates the sympathetic nervous system which is part of the autonomic nervous system and regulates heart rate. Other than this, ether has few side effects. It is an analgesic, and a muscle relaxant.

Although earlier signs of synthesis exist, the first preparation for which written proof exists come from Valerius Cordus, a Prussian botanist, who baptized it “sweet oil of vitriol” in 1540. The name

refers to the sulfuric acid used in his mixture which at the time was known as oil of vitriol. Indeed, ether is obtained by dehydration of ethanol with sulfuric acid at around 140° C.

Thankfully, this process is simple to reproduce with relatively basic equipment. This is discussed in Section #5.1.Ether|outline.

Because of its inflammability and explosiveness, ether was eventually abandoned in rich countries for halothane, the first halogenated ether, in the 1960s (Čižmáriková, Habala and Valentová, 2025).

Chloroform

Chloroform is a compound of formula $CHCl_3$. It is a volatile, colorless liquid sweet odor. As shown in Figure #Synthesis of sevoflurane|graphic, the production of chloroform is relatively simple, it can be obtained by heating at around 500° C a mixture of chlorine and methane. Several other processes exist, for instance in 1831 French scientist Eugène Soubeiran obtained chloroform by mixing chlorine bleach and ethanol.

In 1842, the physician Robert Mortimer Glover writes about the anesthetic qualities of chloroform in his doctoral thesis, but with experiments on dogs. In 1847, the obstetrician James Young Simpson shows the anesthetic effects of chloroform on humans by testing it on two friends and on himself. He reports several advantages of chloroform compared to ether, in particular that the effects are felt faster than with ether (Hoff, 1937). The popularity of chloroform skyrocketed in 1853 after the English physician John Snow gave chloroform to Queen Victoria for the birth of her son (Payne, 1981).

Unfortunately, chloroform was quickly associated with unexplained deaths of patients. The use of chloroform for general anesthesia led to a death rate of patients five times higher than ether. Later, it was found that the use of chloroform in the dosage necessary for anesthesia led to cardiovascular collapse which is not the case with ether for which the dangerous dose is much higher (Morgans and Graham, 2018), chloroform is also associated with liver damage and is a probable human carcinogen based on studies in animals (Winslow and Gerstner, 1978). Thus, despite its interesting properties, chloroform was gradually abandoned, some physicians returned to ether, others used a mixture of alcohol, chloroform, and ether, and all of this will eventually be replaced by halogenated ethers.

Halogenated ethers

Halogenated ethers are a subcategory of ethers that contain at least one halogen atom.

Halothane first synthesized in 1951 by British chemist Charles Suckling became more and more popular after the anesthetist Michael Johnstone endorsed the product in 1956 (Whalen, Bacon and Smith, 2005). Since halothane had undesirable side effects such as associated hepatitis, the search for better halogenated ethers continued for the rest of the 20th century leading to the discovery of other agents such as sevoflurane, isoflurane, and desflurane. Figure #Representation of some ethers used in anesthesia|graphic shows a representation of these molecules.

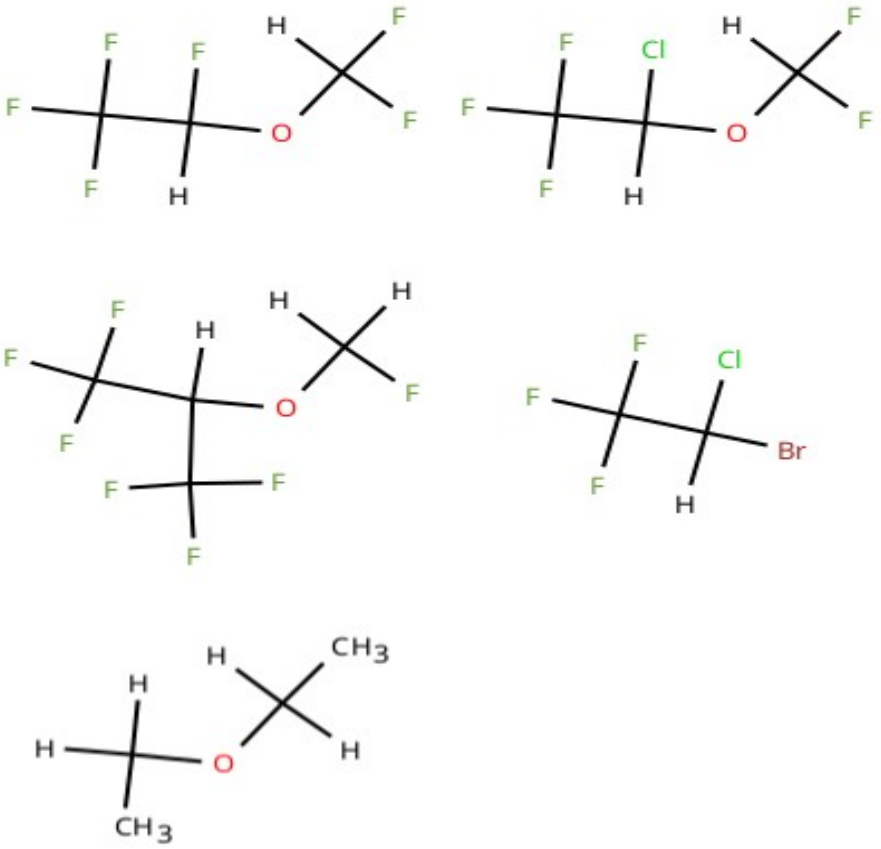


Figure 3: Representation of some ethers used in anesthesia, from top-left to bottom-right: desflurane, isoflurane, sevoflurane, halothane, diethyl ether

The most used inhalational anesthetic today is sevoflurane first synthesized in 1968 but its clinical use started in the 1990s. Sevoflurane is an halogenated ether of chemical formula is $C_4H_3F_7O$. Sevoflurane has a pleasant sweet odor and is nonflammable. It is a vasodilator which can help reduce blood pressure, and a bronchodilator which eases its administration (Barash *et al.*, 2011).

Sevoflurane is fast to act and is eliminated quickly from the body. It doesn’t irritate the lungs on administration. An extensive number of studies on sevoflurane showed the safety of the product. However it has a number of side effects common to halogenated ethers such as calcium dysregulation, and common to many other anesthetics such as postoperative nausea and vomiting, and possible neurotoxicity (Vlisides and Xie, 2012). (Costi *et al.*, 2014) show a higher risk of emergence agitation in children compared to other anesthetics.

Halogenated ethers are potent greenhouse gases. Sevoflurane not as much as its cousin desflurane but still enough to represent a non-negligible part of the contribution of healthcare to global warming (Čižmáriková, Habala and Valentová, 2025). In (Ryan and Nielsen, 2010), authors measured that in terms of carbon emissions, an hour of use of sevoflurane is equivalent of driving 28 kilometers by car in the European Union, against 31 to 62 kilometers for isoflurane and of 375 to 750 kilometers for desflurane. In the article, the authors find that the GWP(20) (twenty-year global-warming potential) for desflurane is 3714, so one tonne of desflurane emitted is equivalent to 3714

tonnes of carbon dioxide in the atmosphere. In comparison, sevoflurane has a GWP(20) of 349, and isoflurane 1401. Generally, operating rooms release these gases in the atmosphere with no treatment. Because of this, desflurane has been gradually abandoned in favor of sevoflurane, since even though theoretically desflurane has better properties, clinically it is not significantly better than sevoflurane making its environmental cost not worthwhile (Van Speybroeck, Mulier and De Baerdemaeker, 2024). Halogenated ethers also degrade in the atmosphere into PFAS such as HFIP and TFA (Kalmar *et al.*, 2024). To reduce their carbon footprint, hospitals thus turned to sevoflurane rather than desflurane. However, the impact of sevoflurane on the atmosphere is still very high, leading some practitioners to use as little halogenated ethers as possible in favor of intravenous solutions such as Propofol.

Although it seems very unlikely that sevoflurane could be synthetized with low-tech solutions, it is interesting to go through its evaluation to compare with potentially low-tech solutions for general anesthesia, and to have a global vision of the complexity achieved in the synthesis of the molecules currently used. A process of production of sevoflurane as close to low-tech as can be according to our research is described in Figure #Synthesis of sevoflurane|graphic. This lengthy process involves sulfur which is not simple to extract, fluorination which is usually electrochemical and requires catalysts such as antimony trichloride, chloromethylation which probably will not be simple to perform in a low-tech world, and manipulation of hydrogen fluoride which is an extremely toxic gas and challenging to store since it is extremely reactive.

Table 2 shows a G analysis of sevoflurane using the low-tech grid. The systematic hypotheses taken are a community of 10,000 people in Toulouse, France, and laws in place to ensure some level of well-being for animals. The distance to fetch some essential materials will very likely be greater than 100 kilometers in particular for sulfur mines in the south of France, although a deeper analysis is necessary to know if there is enough reserves in those mines. Exploiting mines for metals imply significant land system change and pollution, and dangerous and difficult human work. Sevoflurane is also a pollutant in the atmosphere. The transport of materials will likely require animal work. Production and use can only be the work of professionals, the pyrolyses at high temperature will require dependence to the sun in a high-tech world, and sevoflurane is mostly non-reusable.

Table 3 shows a G_0 analysis of sevoflurane using the low-tech grid. Pollution by sevoflurane is still an issue in this version, production and use of sevoflurane is potentially risky, and the molecule is not convivial for the reasons mentioned in the previous analysis, although taking only into account direct use of sevoflurane, it passes the practicality of use criteria.

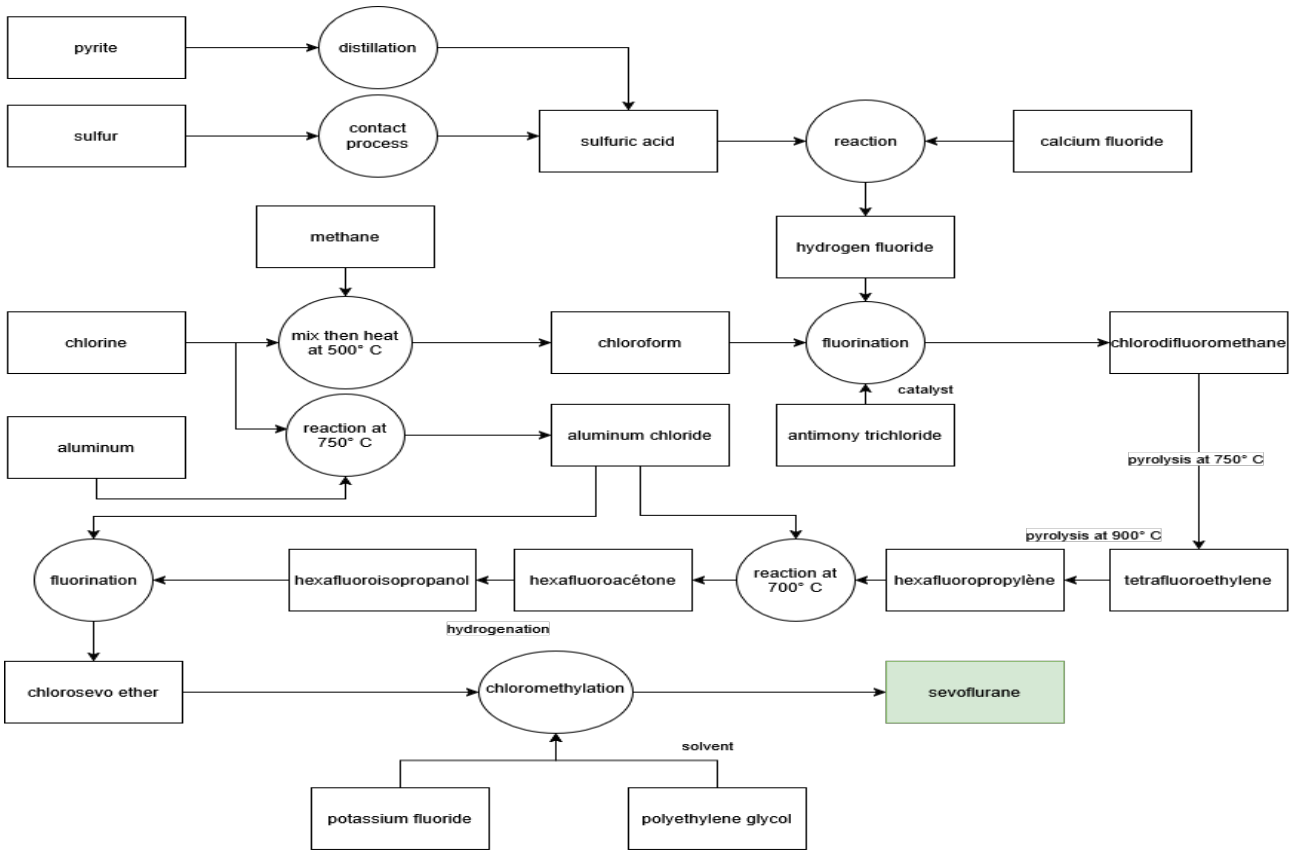


Figure 4: Process of synthesis of sevoflurane

Sources: (Encyclopædia Britannica, 2026c) *(PubChem, 2026) (Moghimi et al., 2015)*

	Sustainability (∞)							Equity (=)			Conviviality (o)			
Sevoflurane	Distance	Land	Pollution	Renewable resource	Non-renewable resource	Necessity	Period of manufacture	Human work	Animal work	Inclusivity	Manufacturing	Complexity of use	Practicality of use	Repairing/ maintenance
	◆	■	■	●	◆	●	■	■	◆	●	■	■	■	■

Table 2: Low-tech grid G for sevoflurane

	Sustainability (∞)							Equity (=)			Conviviality (o)			
Sevoflurane	Distance	Land	Pollution	Renewable resource	Non-renewable resource	Necessity	Period of manufacture	Human work	Animal work	Inclusivity	Manufacturing	Complexity of use	Practicality of use	Repairing/ maintenance
	●	●	■	●	●	●	■	◆	●	●	■	■	●	■

Table 3: Low-tech grid G_0 for sevoflurane

Xenon

Xenon is a chemical element of atomic number 54. It is a colorless, odorless noble gas discovered in 1898 by the Scottish chemist William Ramsay and the English chemist Morris Travers.

The anesthetic properties of xenon were first discovered in 1939 by the American physician Albert Richard Behnke Jr who examined the effects of xenon on deep-sea divers. The first published report on xenon anesthesia came out in 1946 by American medical researcher John Hundale Lawrence who experimented xenon on mice. In 1951, xenon would be first used as an anesthetic agent on two patients by American anesthesiologist Stuart C. Cullen (Jordan and Wright, 2010).

Xenon is a promising lead re-explored in the past decades as a general inhalational anesthetic (Delhaye *et al.*, 2010; Čižmáriková, Habala and Valentová, 2025). Xenon has many interesting properties, it acts very quickly, with a fast recovery, and is not irritant to the lungs (Jin *et al.*, 2019). It is also an analgesic although its effects do not last, and it has very little adverse effects on the heart compared to other inhalational anesthetics. Xenon anesthesia does have a high incidence of postoperative nausea and vomiting, but few other negative side effects.

Unfortunately, its very low concentration in the atmosphere makes it unsuitable for general use (Nakata *et al.*, 1999; Neice and Zornow, 2016). Modern extraction of xenon involves a costly process of cryogenic distillation, or adsorption using complex materials (Banerjee *et al.*, 2018). An anesthetic procedure is at least four times more expensive with xenon than sevoflurane. Because of this, xenon is rarely used for anesthesia nowadays. Thus, xenon anesthesia is very unlikely to be suitable for a low-tech world.

c Intravenous anesthetics

The history of intravenous anesthesia technically starts in 1656, when Christopher Wren used a syringe made from the bladder of a dog and the quill of a goose to inject wine and ale to a dog (White, 2014). In 1665, Johann Sigismund Elsholtz would then become the first to administer opium intravenously to a person.

These experiments showed that it was possible to administer products by injecting them directly into veins, however the products used did not induce anesthesia. It is near the end of the 19th century that true intravenous anesthesia began. In 1872, Pierre-Cyprian Ore used chloral hydrate to treat patients with tetanus, but the mortality rate of his experiments was high (Sear, 2017). Then in 1909, the Russian pharmacologist Nicholas Krawkow demonstrated the anesthetic properties of hedonal, first synthesized in 1899. If hedonal was relatively safe compared to other intravenous anesthetics at the time, it is not very soluble in water thus safe solutions with hedonal was slow to produce anesthesia, and with a slow recovery. In the decade that followed, many agents were tested with limited success, until 1921 when French anesthesiologist Daniel Bardet used a mixture of diethyl and dialyl barbituric acids for intravenous anesthesia.

Barbiturates

Barbiturates are chemicals derived from barbituric acid of formula $C_4H_4N_2O_3$ first prepared in 1864 by the German chemist Adolf von Baeyer.

In the 1930s, studies investigate different barbiturates for intravenous anesthesia after some previous successful experiments. In 1932, German doctors Hellmut Weese and Walter Scharpff report the synthesis of hexobarbital, an intravenous anesthetic with a high incidence of excitatory side effects. In 1934, American anesthesiologists John Lundy and Ralph Tovell report clinical use of thiopental, called thionembutal at the time, on thousands of patients (White, 2014). American anesthesiologist Ralph Milton Waters also published results on the use of thiopental for general anesthesia (Radkowski *et al.*, 2024). Sodium thiopental or thiopental is an intravenous anesthetic of chemical formula $C_{11}H_{17}N_2NaO_2S$ with a fast onset and a quick recovery. Thiopental has no analgesic properties, and without the use of other agents, large doses were required to prevent movement during operation which caused cardio-respiratory depressions and longer recoveries.

Benzodiazepines

Benzodiazepines are chemicals which core is composed of a benzene ring, a hydrocarbon ring composed of six carbon atoms, and a 1,4-diazepine ring, a chemical ring composed of five atoms of carbon and two atoms of nitrogen.

The Polish American chemist Leo Sternbach working on the synthesis of new sedatives discovered chlordiazepoxide, the first benzodiazepine, in 1955 (Sternbach, 1979). The search for an agent with less undesirable side effects led to the discovery of midazolam in 1975, which is to this day the most commonly used benzodiazepine for sedation. In the late 1990s, another benzodiazepine called remimazolam ($C_{21}H_{19}BrN_4O_2$) was discovered, with interest spiking in the past years due to its faster onset and recovery times, as well as less side effects. Research for the use of remimazolam as a general anesthetic is currently underway with interesting results (Aubrun, 2025).

Modern benzodiazepines synthesis involve very complex processes that are unlikely to be replicable with low-tech solutions (Jagadale *et al.*, 2023).

Propofol

Propofol (2,6-diisopropylphenol) is an intravenous anesthetic of chemical formula $C_{12}H_{18}O$. It is one of the most used anesthetics due to its interesting properties. Propofol is effective quickly for a relatively predictable time, and recovery is fast with few side effects compared to other anesthetics (Barash *et al.*, 2011).

Intravenous anesthetics have the advantage over halogenated ethers of not being greenhouse gases, so they do not contribute directly to global warming and destruction of the ozone layer. However, they are still harmful to the environment as they pollute water and soil. Released in the environment when discarded during an operation or excreted by patients, it is highly ecotoxic and can only be destroyed by incineration in high temperatures (Pauchard *et al.*, 2023). Recent results show that when taking into account the entire life cycle of propofol, its carbon footprint is close to the one of sevoflurane, although with the hypotheses of optimal use of halogenated ethers and a high rate of recapture and recycling of gases.

Unfortunately, propofol is not likely easy to produce with low-tech solutions since it involves a complex alkylation process involving toluene. Additionally, intravenous anesthesia generates other kinds of issues such as plastic pollution due in part to the use of disposable syringes, and water contamination (Jabaudon *et al.*, 2024; Bernat *et al.*, 2025).

Ketamine

Ketamine is an intravenous global anesthetic of chemical formula $C_{13}H_{16}ClNO$ with interesting properties that make it invaluable in modern anesthesia, in particular when advanced equipment or specialized personnel are not available, in particular in emergency or war conditions (Kurdi, Theerth and Deva, 2014; Nahle, Nunez and Msheik, 2026). It is a bronchodilator which makes it a good agent for people with bronchospasm, and it has been used clinically since the 1970s.

Ketamine is also widely used in veterinary anesthesia since it has been tested as a safe and efficient agent for a variety of species.

Ketamine production involves a complex process based on petrochemicals such as tetrahydrofuran or cyclohexanone (Zekri, Fareghi-Alamdari and Momeni-Fard, 2020). Thus, ketamine is unlikely to be a solution for low-tech communities.

d Mechanisms of action

The mechanisms of action of general anesthetics are still not fully understood. This section briefly reviews what is known of these mechanisms.

General anesthetics act on specific parts of the brain. Ligand-gated ion channels, formed of proteins that allow ions to pass through the membranes in response to neurotransmitters, are the usual targets of general anesthetics (Diao, 2014), in particular the gamma-aminobutyric acid type A ($GABA_A$) receptor inhibited by the neurotransmitter γ-aminobutyric acid (GABA) of chemical formula $C_4H_9NO_2$ which is the main inhibitory neurotransmitter in the central nervous system. General anesthetics enhance inhibitory neurotransmitters such as GABA, and reduce excitatory neurotransmitters such as glutamic acid. The enhancement of GABA is considered the primary mechanism of general anesthetics. Some agents also prevent the mechanism of desensitization of $GABA_A$ receptors to the continuous presence of GABA, and others even directly inhibit $GABA_A$ without GABA. Sedatives also act on $GABA_A$ receptors, but for hypnosis required for anesthesia a higher concentration of anesthetic is required.

Some general anesthetics target other ion channels. Nitrous oxide and xenon act as N-methyl-D-aspartate (NMDA) receptor antagonists but have little effect on $GABA_A$ receptors. The NMDA receptor is a glutamate receptor and an ion channel found in neurons and involved in synaptic plasticity, learning and memory formation (Brown and Sneyd, 2016).

Because of their mechanisms of action, most general anesthetics are potentially neurotoxic in various ways (Vlisides and Xie, 2012).

B Local anesthetics

This section gives a short and incomplete history and low-tech analysis of local anesthetics.

In Latin America grows plants called the coca plants containing the psychoactive molecule called cocaine ($C_{17}H_{21}NO_4$). Proofs of human use of coca leaves go back as far as 5000 years ago (Calatayud and González, 2003). The leaves were used to reduce hunger, thirst, and pain, and to not feel the heat of the sun. Europeans discovered the properties of coca leaves during the colonization of Latin America, with the first records dating from the beginning of the 16th century. In 1860,

German chemist Albert Niemann managed to isolate cocaine. In 1884, the Viennese ophthalmologist Carl Koller performed the first operation using cocaine as local anesthetic. Its use then spread rapidly but soon dangerous side effects were reported. A while later, it was found that side effects could be mostly avoided by using lower concentrations, but the high addiction potential pushed chemists to find other molecules for local anesthesia.

In 1904, German chemist Alfred Einhorn patented new molecules including novocaine also called procaine which became the new standard for local anesthesia. However, this new molecule was not very potent, and some people were highly allergic to it.

Many other chemicals were created later such as lidocaine, which is one of the most used local anesthetic including in dentistry, with a stronger effect than procaine and less allergic reactions (Tetzlaff, 2000).

Local anesthetics reversibly block nerve signals. Axolemma is the cell membrane of an axon. The axon is a projection of a nerve cell which conducts electrical signals. Pain is felt when sodium ions travel quickly in the axolemma, and the electric signal propagates from nerve cell to nerve cell. Local anesthetics prevent this propagation with two mechanisms, by compressing the sodium channels, and by linking to the receptors that trigger the opening of those channels. This happens when local anesthetics are in a sufficient quantity to spread in tissues and enter in protonated form.

Although current agents used for local anesthesia can probably not be produced with low-tech solutions, cocaine could be a solution where coca plants grow, and some oils from plants such as clove oil show some potential as effective local anesthetics (Havale *et al.*, 2021). More research is necessary to give a more accurate overview of practices in local and regional anesthesia, and a more thorough low-tech analysis.

C Equipment in anesthesia

Modern anesthesia makes use of a sizable quantity of medical equipment with various degrees of technological complexity.

a Types of equipment

It is common for surgical patients to receive pure oxygen instead of air during anesthesia to reduce the risk of hypoxemia (Suzuki, 2020). Oxygen are stored in cylinders usually made of molybdenum steel.

Ventilators are used for assisted ventilation when patients cannot breathe on their own. Typically in general anesthesia, people no longer breathe on their own, so ventilators are required. Ventilators can be very sophisticated and controlled by a computer, or can be simpler such has mechanical bag valve masks.

Face masks used to ventilate the patient are made of rubber, silicone, or more often see-through plastic to monitor the condition of the patient. Reusable masks exist, but they are still made of plastic and if they are not one-use they must still be disposed of after a number of uses (Webb *et al.*, 2025). Tracheal tubes are catheters inserted into the trachea to allow for mechanical ventilation by establishing a patent airway. Humidification devices (Gaffney and Dalton, 2021) add water vapor to a gas, and is necessary for anesthesia since it bypasses the nasopharynx which is responsible for air

humidification during normal breathing. Failure to add water to the inspired gas can lead to unwanted complications such as thickening of respiratory secretions.

Rotameters allow to measure the quantity of air flow. Monitoring equipment to detect respiratory problems as early as possible include capnographs which monitor the concentration of carbon dioxide in breath, and pulse oximeters which monitor blood oxygen saturation. Capnographs measure the absorption of infrared light by carbon dioxide, and pulse oximeters measure the absorption of red and infrared light by blood to determine the ratio of oxyhemoglobin. Therefore both devices require at least a light-emitting diode, a detector, and an electronic processor. In (Tinker *et al.*, 1989), anesthesiologists were asked if additional monitoring devices could have prevented negative outcomes in past cases, and they judged that nearly a third of those negative outcomes could have been prevented with capnographs and pulse oximeters.

There are also oxygen analyzers to determine the concentration of oxygen in breath and detect problems in the main oxygen supply source, spirometers to measure the volume of air inspired and expired, airway pressure monitors to determine various patient ventilation parameters, electrocardiographs to measure heart rates and detect cardiac arrests, all of these obviously equipped with visual and auditory alarms.

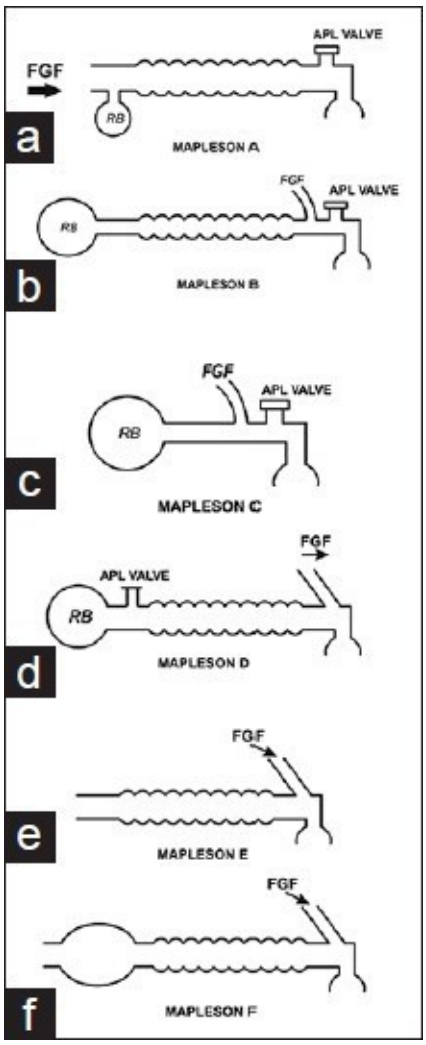
Hospitals are pushed by the industries of medical equipment to keep buying their newest, higher-tech machines. Even stethoscopes are electronic now and offer information that is useless most of the time. As a consequence, hospital staff is no longer able to do basic maintenance on their tools, and specialized companies ask for a high price to repair them, sometimes causing hospitals to leave machines out of order for an extended period of time.

b Breathing systems

The systems that conduct anesthetic gases to the patient are known as breathing systems or breathing circuits.

The oldest systems called open systems simply consisted in soaking fabric with an anesthetic, and holding the fabric with or without a mask near the face of the patient who would breath the anesthetic with ambient air. This is called "open drop" anesthesia (Messer, 1914). These systems had many disadvantages, they worked only if the patient could breath on their own, there was no way to monitor the concentration of anesthetic inspired, they could only administer one inhalation agent at a time, and anesthetic could come in contact with the skin resulting in inflammations or eye irritation.

With time, many different systems were created to improve safety, ease of use, and comfort for the patient. These systems would completely replace breathing the surrounding air with controlled source of fresh gas flow (FGF), thus they are called closed or semi-closed systems depending on the complete or partial re-breathing of exhaled gas. In 1954, the British physicist William Mapleson designed a classification of five types for semi-closed breathing systems, with a sixth type added in 1975 (Kaul and Mittal, 2013). Figure #Mapleson systems|graphic shows diagrams of the Mapleson systems.



FGF = Fresh Gas Flow
APL = Adjustable Pressure Limiting
RB = Reservoir Bag

Figure 5: Mapleson systems
Source: (Kaul and Mittal, 2013)

In the Mapleson A system also known as the Magill circuit, as shown in Figure #Magill circuit| graphic, FGF enters from the end of the T-tube (F) into the corrugated reservoir tube (R) which connects the reservoir bag (B) to the adjustable pressure limiting (APL) valve (V). When the patient inspires, the APL valve closes and fresh gas is breathed from the reservoir tube, and this gas is replaced by the fresh gas in the reservoir bag. When the patient expires, the reservoir tube is filled with expired gas, and the reservoir bag is filled with fresh gas. Toward the end of expiration and until the next inspiration, pressure from the reservoir bag opens the APL valve rejecting expired gas out of the system and filling the reservoir tube with fresh gas. A modification called the Lack system moves the APL valve next to the FGF for convenience of use.

This system works best for spontaneous breathing, but is inefficient in controlled ventilation, during which pressure is applied to the reservoir bag for inspiration, as a lot of fresh gas must be wasted in order to avoid re-breathing of expired air.

The reservoir bag is made of rubber or plastic, it avoids excessive pressure on the patient, acts as a visual feedback of the patient breathing, and allows for controlled ventilation. The reservoir tube is corrugated to avoid collapse when bent and to avoid leaks when stretched. Most corrugated

anesthesia tubes are made from polyethylene for flexibility or polypropylene for better resistance to products such as disinfectants.

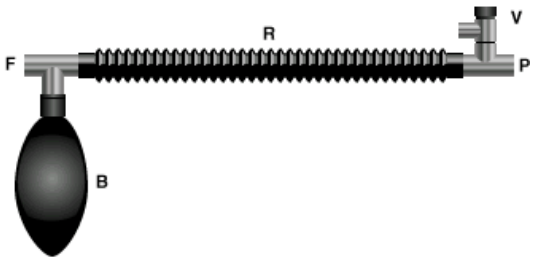


Figure 6: Magill circuit
Source: asevet.com

Mapleson B and C are similar in design, they require high flows of gases to prevent rebreathing. Mapleson B was abandoned, but Mapleson C is still used in intensive care (McCarthy and Harte, 2024).

Mapleson D, E and F are also very similar. They differ only on the mean to release gas either with an APL valve (D), an open-ended tube (E), or an open-ended bag (F). Mapleson E and F are mostly used for pediatric anesthesia since spontaneous breathing is easier with these systems. Mapleson D is the most efficient Mapleson system for controlled ventilation. When the patient inspires, fresh gas is breathed from the reservoir bag and the FGF. When the patient expires, the reservoir tube and the reservoir bag are filled with expired gas and fresh gas. When pressure is high enough, expired gas and fresh gas are expelled through the APL valve. Before the next inspiration, expired gas is pushed through the APL valve by fresh gas. However, if the FGF is not strong enough to purge the expired gas in time, re-breathing of expired gas occurs. And if the FGF is too strong, hypocapnia may occur. A modification of Mapleson D called the Bain system moves the FGF to be co-axial to the reservoir tube.

To combine the advantages of Mapleson A, D and E, David Humphrey created a circuit called the ADE system that can be changed from a Mapleson A to a Mapleson D by moving a lever next to the FGF, and to a Mapleson E by leaving open the FGF.

To reduce waste of systems such as the Mapleson D which requires a high FGF to avoid too much re-breathing of expired gas, systems called circle systems were created with their first use dating in 1926. These systems are widely used today, in particular because they reduce the amount of gas used which is interesting since, as explained earlier, modern anesthetics are potent greenhouse gases. Circle systems as shown in Figure #Circle system|graphic are composed of an APL valve, a carbon dioxide absorber, a fresh gas inlet connected to a fresh gas flow source with a vaporizer for the anesthetics, a reservoir bag, and two one-way valves to obtain a one-way circulation of gases. Some circle systems are totally closed, with a closed APL valve, or no APL valve at all, but with closed systems there is a risk of pressure buildup that may pressure the lungs of the patient or the reservoir bag.

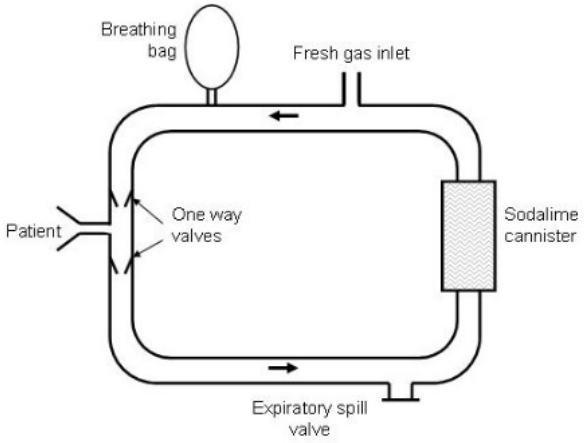


Figure 7: Circle system
Source: (McCarthy and Harte, 2024)

Soda lime, a mixture of sodium hydroxide (NaOH) and calcium hydroxide ($Ca(OH)_2$), is used as carbon dioxide absorbent to avoid carbon dioxide poisoning in such systems were re-breathing of expired gas is much higher. Soda lime also contains water, roughly a third of its mass, to allow the reaction to take place. Absorption of carbon dioxide by calcium hydroxide in the presence of water generates calcium carbonate ($CaCO_3$), water, and heat, with the sodium hydroxide serving as a strong base catalyst. Sometimes sodium hydroxide is substituted with other alkalis such as potassium hydroxide (KOH). However, these products may degrade the anesthetics into toxic compounds such as pentafluoroisopropenyl fluoromethyl ether, also known as Compound A, and carbon monoxide (Fang *et al.*, 1996; Rogalewicz *et al.*, 2020). To prevent this, carbon absorbents have been produced with only calcium hydroxide as the reactant, providing slower but safe absorption.

To deliver the gas into the circuit, there are two main types of ventilators, bellows ventilators which use compressed air or oxygen to compress a separating collapsible bag called bellows which contain the gases to administer to the patient, and piston or turbine ventilators which use an electric motor to power either a piston mechanism or a turbine. Although bellows ventilators require more gas, they do not require electricity which is of interest to us for our research.

In addition to their basic components, modern systems include a lot of sensors, controllers, alarms, software, emergency oxygen supplies, battery backups, screens displaying information (Coisel *et al.*, 2014).

c Low-tech equipment

In a low-tech world, many things taken for granted in modern hospitals may no longer be available, including electricity. Some of the equipment used in modern health facilities of rich countries can be made with materials which are likely compatible with a low-tech world. For instance, rotameters can be made from glass for the tube and ceramic for the weight inside. However it is not the case for the electronic equipment and thus for most of the monitoring tools. Endotracheal tubes, catheters, syringes, and masks could pose a real challenge to manufacture or find alternatives in a low-tech world. If there are some existing work for low-cost spirometers such as (Verma and Verma, 2023), these still require electronic components and sensors.

Additional work is necessary to manufacture low-tech compatible equipment for anesthesia.

V Existing research and perspectives

Some modern models of healthcare attempt to look at our current system with a critical eye. Some even question our reliance on technology and innovation.

Health Care without Harm (Health Care Without Harm, 2026) is an NGO working with hospitals and political organizations to implement a healthcare system with less environmental impact, which mostly implies reducing waste and greenhouse gas emissions of the healthcare sector.

Social medicine (Cohen, 1968) is a field that aims to understand how the social, economical, political, and environmental context impact health, and to think about how to address problems associated with this context, acting on the primary causes to reduce health problems rather than treating the consequences.

Realistic Medicine (Fenning, Smith and Calderwood, 2019) is a Scottish model of healthcare that aims to improve care by improving the relationship between the patient and the healthcare professional, taking into account the personal preferences of the patient and making sure their consent is respected, and reducing variation in treatment.

In Wales, Prudent Healthcare (Welsh Government, 2016) aims to reduce spending and improve health by reducing unnecessary tests and treatments. Less is More is a movement that is also being implemented in medicine with the same goals (Kherad *et al.*, 2020).

Slow Medicine (Slow Medicine Foundation, 2026) aims to make sure that the patient and the healthcare professional have enough time to understand what the patient needs, with consent as central and doctors guiding the patient towards better health rather than deciding for them. This movement also questions modern practice of medicine such as using plants from the other side of the world to heal minor diseases in rich countries.

In (Kaplan and Porter, 2011), authors show that the cost and complexity of current healthcare could be reduced in a collaborative approach that would even improve care.

Community-based care is recognized by WHO as an essential part of health systems.

However, even in these models, modern technology in anesthetics, and healthcare in general, is rarely criticized. Lower-tech or low-tech solutions are considered inferior, or even archaic, but still worthy of research because these solutions are seen as useful for low-income countries (Chang *et al.*, 2015), for medical deserts (Orser *et al.*, 2019), and in any other situation where hospitals equipped with state-of-the-art medical technology are inaccessible, either because they are too expensive, or out of reach such as during military operations (Peoples *et al.*, 2005; Morgans and Graham, 2018). The possibilities and benefits of generalizing lower-tech or low-tech solutions, even for environmental reasons, are not explored enough. Imperialist healthcare materialized by the plunder of resources and the exploitation of inhabitants of low-income countries for the care of the richest is not questioned. There is little reflection on the impact and desirability of the replacement of traditional and community-based ways of caring, healing, suffering, and dying with dependence to unsustainable “heroic” medical interventions (Illich, 1976).

Some initiatives (Sarfati *et al.*, 2024) start to question what would healthcare look like in a world where high-tech is extremely limited or absent. LowTekMed (LowTekMed, 2026) is a very recent group of medical practitioners of various fields which aims to advance research in reliable solutions for institutional care, raise awareness about the unsustainability of the current system, and discuss ethical considerations about healthcare.

Very few papers explicitly claim to work on low-tech anesthesia, and these papers only mention the term but do not dwell on the concept. Nevertheless, these works are still of interest to the low-tech community. In (Sherman, 2016; Laumonerie *et al.*, 2019), authors discuss regional anesthesia techniques for shoulder surgeries. This type of anesthesia requires precision for safety and effectiveness. Modern techniques involve the use of ultrasound guidance and electric stimulation. The cited papers show that it is possible for the surgeon to perform anesthesia for shoulder operations using familiar anatomic landmarks as guidance instead of sophisticated equipment and the assistance of an anesthetist. These papers show that there are ways to perform some medical operations without dependency to high-tech equipment.

Most articles of interest do not directly refer to low-tech. They write instead about low-cost medicine, austere environments, low and middle income countries (LMICs), healthcare in the developing world. However, some of these are still of interest to us since they mostly explore ways to perform anesthesia with less resources and equipment, cheaper products which usually means they are easier to produce, and more accessible techniques.

For instance, in (Deepak *et al.*, 2019), authors report a device made with limited resources for airway topicalization of lidocaine (see Figure #Low-cost airway topicalization device|graphic). In (Kuczkowski and Chandra, 2008), the authors show that satisfactory pain management during labor can be achieved with a single-dose spinal analgesia. They recommend this technique as an alternative to epidural analgesia in Indonesia and other developing countries. The article does not discuss the potential of using this technique on a more global scale, which is the case for most papers on the topic of achieving anesthesia in contexts where state-of-the-art equipment, highly trained personnel and expensive molecules are not available.

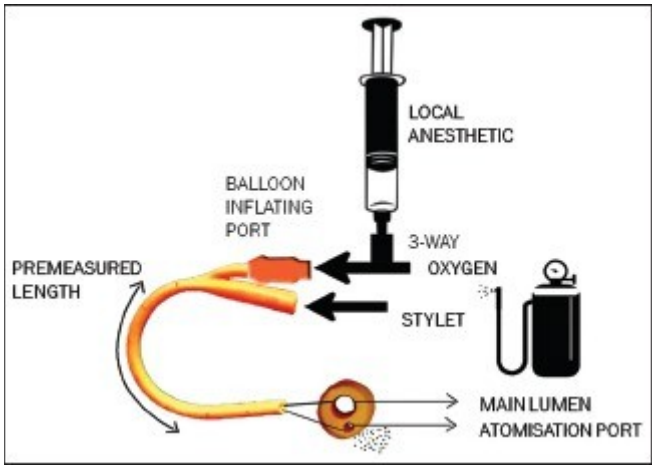


Figure 8: Low-cost airway topicalization device

The better understanding of the human body and the capacity to create more sophisticated chemicals led to the development of many anesthetics, but the benefits of modern agents for general anesthesia compared to ether are unclear (Whalen, Bacon and Smith, 2005).

i Ether

Ether is not only the first reliable and safe anesthetic agent, it is also the second longest used molecule for anesthesia, more than a century, after nitrous oxide.

Ether is an analgesic and a muscle relaxant which are good properties for a sole agent for anesthesia, it also has a fast onset time. In 1920, the American anesthesiologist Arthur Guedel developed a system based on observable physical signs such as regularity of the respiration, eye movement, secretion of tears (Morgans and Graham, 2018). This system is usable even by non-practicians to administrate ether safely.

As discussed earlier, ether has few unwanted side effects. It does trigger more postoperative nausea and vomiting than more modern inhalational agents, which is not just uncomfortable, it also increases recovery time and may trigger other complications. There are known ways to reduce postoperative nausea and vomiting, for instance in (Hu *et al.*, 2025), authors detail practice guidelines to avoid or reduce these side effects in particular using other chemical agents, but also massages, hypnosis, alternative medicine, or music.

Its flammability was problematic and the cause of fires and explosions (Macdonald, 1994), especially when ether was used in combination with nitrous oxide and oxygen. However, incidents occurred relatively rarely and their causes were either complete carelessness in manipulation of the product, faulty equipment, or administration of ether in an open or semi-open system, which would then spread ether in the surrounding atmosphere, in an environment with a heat source such as a fire, a hot instrument, or an electric spark. It is very likely that with appropriate safety measures for its storage and manipulation, the use of ether for anesthesia would be safe. Ether is still used today as a solvent and in fuel mixture, and thus safety precautions for handling this product are well known (Singh, Kaushik and Chawla, 2024). Ether should be stored in airtight, opaque containers, and in a dry place away from sunlight and heat. When administered, open flames must be prohibited, as well as unsafe material without proper protection (Chang *et al.*, 2015). It must be noted that although very rare, similar incidents occurred with modern agents, for instance (Wu *et al.*, 2004) reports a case of explosion and fire caused by sevoflurane and barium hydroxide lime used as carbon dioxide absorbent.

Research on ether anesthesia has pretty much stopped since the 1960s. Thus, low-tech research on the subject is necessary to efficiently adapt the use of ether with the new knowledge acquired in the past decades.

As mentioned in an earlier section, ether is obtained by the dehydration of ethanol with sulfuric acid at around 140° C. Ethanol can easily be produced with fermentation of sugar using yeast. One process to synthesize sulfuric acid requires sulfur to be burned to produce sulfur dioxide, which is then oxidized to produce sulfur trioxide, which is then hydrated into sulfuric acid. The main problem of this process is the access to sulfur which is found mostly in volcanic regions. The heat, the toxic fumes, the acidic water, the physical toll of carrying solidified sulfur out of craters, make

sulfur extraction extremely dangerous. Another way to obtain sulfuric acid is the oxidation in the presence of oxygen and water of pyrite (FeS_2) which is a relatively abundant mineral (Dos Santos, De Mendonça Silva and Duarte, 2016). There are other ways such as the historical lead chamber process which involved the oxidation of sulfur dioxide with moist air in chambers of lead.

The dehydration by itself requires a source of heat but the required temperature (140° C) is low enough that it is easy to reach even in a low-tech setting. However, a difficulty is control of the temperature, as if it is too low the reaction does not occur, and if it is too high, ethylene is produced, which is another potentially useful chemical but not as an anesthetic. The process also requires some glass containers, a fractional column to allow for distillation, and a dropping funnel that allow for the administration of ethanol drop by drop into the sulfuric acid. For storage, ether requires something that blocks sunlight such as an amber glass bottle, that can be well sealed. Ideally the bottle should be filled entirely to avoid contact with oxygen.

Table 4 shows a G analysis of ether using the low-tech grid. The systematic hypotheses taken are the same as for sevoflurane (see Section #4.1.1.2.4.Halogenated ethers|outline). The distance to fetch sulfur or pyrite in sufficient amount will likely be greater than 100 kilometers. Exploiting mines for metals imply significant land system change and pollution, and dangerous and difficult human work. The transport of materials will likely require animal work. Production and use is not very complex, but enough so that not everyone would be able to make or use ether. Ether is mostly non-reusable. In conclusion, ether seems relatively acceptable as a low-tech solution, but integrating it in a low-tech system would likely require some work for the low-tech synthesis of sulfuric acid.

	Sustainability (∞)							**Equity (=)**			**Conviviality (o)**			
Ether	Distance	Land	Pollution	Renewable resource	Non-renewable resource	Necessity	Period of manufacture	Human work	Animal work	Inclusivity	Manufacturing	Complexity of use	Practicality of use	Repairing/ maintenance
	♦	■	■	●	♦	●	●	■	♦	●	♦	♦	●	■

Table 4: Low-tech grid G for ether

ii Hypnosis

Hypnosis is described as “a state of consciousness involving focused attention and reduced peripheral awareness characterized by an enhanced capacity for response to suggestion” (Elkins *et al.*, 2015). Although research on the subject is not directly classified as low-tech, hypnosis does not require drugs or equipment, and is a technique that can be applied and taught to everybody, which makes it a very good candidate.

Records show that hypnosis was used in the 19th century to perform painless childbirth, tooth extractions, and operations such as incisions, ablations, and amputations (Hammond, 2008; Slater, Van-Manen and Cyna, 2024). This was all just before the first modern anesthetics became available.

More recent successful applications of hypnosis for anesthesia have been documented even for heavy surgical operations (Botta, 1999; Wain, 2004; Facco *et al.*, 2013; Cossu *et al.*, 2024) which makes it a promising low-tech tool for anesthesia.

In (Eberhart *et al.*, 1998), authors show in a double-blind randomized study that hypnosis can be used to significantly decrease postoperative nausea and vomiting.

In dentistry, there are a decent number of documented cases of anesthesia using hypnosis to reduce pain and stress (Holdevici, Crăciun and Crăciun, 2013; Glaesmer, Geupel and Haak, 2015; Motallebi *et al.*, 2024; Leonan-Silva *et al.*, 2025). Hypnosis is efficient as local anesthesia in dental operations including tooth extraction, and for the management of dental anxiety (apprehension and fear around dental treatment) (Merz *et al.*, 2022; Thibault, Rainville and Rei, 2025). Use of this technique allows for diminution of the necessity for medication administered for pain and stress management before, during, and after a medical procedure (Mackey, 2018; Dilmahomed and Jovani-Sancho, 2019). In particular, data suggests that hypnosis helps recovery after sedation (Dyas, 2001; Merz *et al.*, 2022).

Hypnosis could also help to reduce bleeding during operations, but the evidence does not seem conclusive at this point. In (Montenegro *et al.*, 2017), authors report that hypnosis was effective to reduce anxiety, bleeding, and pain during an implant placement, but in (Efsun Ozgunay *et al.*, 2019), a study on 22 patients finds that if hypnosis decreased pain during and after rhinoplasty with reduced usage of analgesics, authors conclude that intraoperative bleeding was not affected.

Hypnotic anesthesia has its limits. People have variable hypnotic susceptibility, which means that if for some hypnosis can be used as sole anesthesia even in complex operations, for others this technique has very limited effects. Some tests such as the Stanford Hypnotic Susceptibility Scales have been developed by psychologists to measure how easily a person can be hypnotized. In cases where the pain or stress is very strong, hypnosis is rarely enough and analgesics must still be administered although in a lesser amount (Cossu *et al.*, 2024). There is no standard way to induce hypnosis in patients, so various techniques are observed in the literature which may use directives from the hypnotherapist, music, recordings, cognitive therapies, conversations, with different efficiencies (Merz *et al.*, 2022).

Hypnosis is a very promising technique to complement anesthetics in various cases for pain management, loss of consciousness, and post-operation recovery. However, its value for anesthesia remains inconclusive due to the lack of high-quality data on the subject (Lahoud, Gurary and Elia, 2026). Thus, further research is necessary to confirm its usefulness, to better understand how to induce hypnosis efficiently, and to define standardized protocols.

VI Conclusion

Anesthesia has a rich but relatively short history. Simple chemicals and equipment that was involved at the origin of the medical field has gradually been replaced with agents obtained by long processes involving fossil fuels and electricity, and complex technology.

Diethyl ether is a component that has been used for general anesthesia for more than a century in the Global North, and is still used today in countries that cannot afford the modern and expensive

molecules and equipment. The main reason to abandon the molecule was its inflammability, but research suggests that accidents were rare and occurred when proper safety measures were not followed. With the knowledge obtained in 70 years since the decline of ether, there is hope that modern medicine could find a way to reintroduce this anesthetic.

Hypnosis shows promising results. The charlatanry around the practice restrained research for a long time, but recent studies show that hypnosis could at least reduce stress and need for post-operative care, and at best reduce drastically the amount of anesthetics used. Research is needed to confirm the results and define standard practices of clinical hypnosis.

For local anesthetics, this work is very lacking in data and research to draw conclusions, but some natural products such as clove oil could potentially be efficient enough for a low-tech world.

Finally, research shows that a profound change in needed in the philosophy of the healthcare system. The dependency to high-tech solutions, the lack of consideration of the expertise of patients on their own health, and the cost-effective politics on care, preventing doctors and patients to spend the time required to heal, and leading to shortage of important but non-profitable medicine, go against the very goal of the healthcare system. All of the best changes in technique will not be enough to obtain low-tech healthcare without a democratic debate on what it means to be healthy, and profound systemic change.

VII Artificial intelligence

No generative artificial intelligence (GenAI) was used at any point in the research and writing of this work. Any use of this publication as input for generative artificial intelligence technologies is expressly prohibited.

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