WO-10 Putting the patient to sleep: ether, chloroform, nitrous oxide, ketamine, and making them

HEALING after the FALL, research library, WO-10

Researched 10 October 2026 by Claude Opus agent for THRIVING after the FALL, Book Four. Library document, unverified.

Scope. History, evidence of benefit and harm, dose, signs of overdose and feasibility only. No synthesis or manufacturing procedure, reagent quantity or purification step is given. Section 1.9 explains why.

1. Findings by section

1.1 Why sleep matters, and what this report sits beside

The abdomen report concluded that a district can open an abdomen only under "local or ketamine" anaesthesia. It left the question of safe anaesthesia for laparotomy to this report (THRIVING library, WO-08). The humanitarian medicine report found that the ICRC runs its surgical hospitals without ventilators, largely on ketamine. Postoperative mortality there ran from 2.2% (Quetta) to 6.1% (Monrovia) (THRIVING library, FO-11). The burns report assumes that escharotomy and skin grafting are done under ketamine (THRIVING library, WO-04).

Local and spinal anaesthesia and the non-drug methods belong to WO-11, which was not yet in the library. This report covers general anaesthesia: making a person unconscious or dissociated so that a surgeon can cut, then bringing them back.

The ICRC war surgery manual states the stakes plainly. "All anaesthesia is potentially fatal", and there is "no such thing as a 'small' anaesthesia" (Giannou and Baldan 2010). Every agent below kills by the same few routes:

- breathing stops
- the tongue and soft palate block the airway
- stomach contents enter the lungs
- the heart stops or loses its rhythm
- the vapour catches fire
- the drug wears off before the surgeon is done.

The choice of agent changes which of these is most likely. It never removes them.

1.2 The discovery, 1842 to 1847

What the tradition says. Ether Day, 16 October 1846, is the founding story of anaesthesia. William Morton, a Boston dentist, put Edward Gilbert Abbott to sleep in the operating theatre of the Massachusetts General Hospital. John Collins Warren then removed a tumour from Abbott's neck (Wikipedia, "Edward Gilbert Abbott"). Morton disguised the agent under the name "Letheon". He had already drawn a tooth painlessly on 30 September 1846, and Henry Jacob Bigelow arranged the hospital demonstration. Morton also tried to patent the agent [VERIFY].

What the record shows. Others came first.

- **Humphry Davy, 1800.** He wrote that nitrous oxide "may probably be used with advantage during surgical operations". Nobody acted on it for 44 years (Wood Library-Museum, Davy 1800).
- **Crawford Long, 1842.** A country doctor in Jefferson, Georgia, he removed a neck tumour from James Venable on 30 March 1842 using a towel soaked in ether. He published only in 1849 (Wikipedia, "Crawford Long").
- **Horace Wells, 1844 to 1845.** A Hartford dentist, he saw Gardner Colton's laughing-gas show on 10 December 1844 and had his own tooth drawn under nitrous oxide the next day. His demonstration in Boston in January 1845 failed when the patient cried out, and the audience called it humbug (Connecticut History, Wells).

It reached the field within a year. In 1847 Nikolai Pirogov gave ether by the rectum, a route Roux had suggested. He then used ether in the field at the siege of the aul of Salta in the Caucasus on 9 September 1847 (Wikipedia, "Nikolay Pirogov").

What modern science infers. Long had a working result and taught no one. Wells taught but failed in public. What spread the method was a public demonstration, a written account and a hospital that adopted it. A district with ketamine but no written protocol or training is in Long's position.

1.3 Chloroform: fast, pleasant, and lethal to the healthy

What the tradition says. James Young Simpson, professor of midwifery in Edinburgh, tried chloroform on himself and his friends on 4 November 1847. He read his paper to the Medico-Chirurgical Society of Edinburgh on 10 November (general-anaesthesia.com, chloroform. Wood Library-Museum, Simpson). The text speaks of "upwards of thirty individuals", and a postscript to a later printing speaks of fifty cases. Samuel Guthrie in the United States and Eugène Soubeiran in France had each made chloroform in 1831.

Chloroform had real advantages over ether:

- it acted faster
- it did not irritate the airway
- it did not burn
- a small bottle went a long way.

For seventy years it was the main anaesthetic of Britain and the German-speaking lands. It was used in an estimated 80 to 95% of anaesthetics there from about 1865 to 1920 [VERIFY, secondary summary only].

What the record shows: the first death. It came eleven weeks after Simpson's paper. John Snow recorded the details in his book (Snow 1858).

Hannah Greener, 15, of Winlaton near Newcastle, was having a toenail removed on 28 January 1848. Ether had been used on her other foot the previous November without trouble. Dr Meggison gave about a teaspoonful of chloroform on a handkerchief, and within half a minute she was insensible. At Mr Lloyd's incision she kicked, her lips blanched, she spluttered, and she died. Cold water, brandy and opened veins in the arm and neck brought nothing. Snow says the whole affair took no more than two minutes.

Some later accounts give the date as 18 January. A modern review discusses whether she died of a heart arrhythmia, of brandy inhaled into the lungs, or of overdose, and does not settle it (Knight and Bacon 2002, abstract only).

What the record shows: one careful man against the averages. Snow gave chloroform in "upwards of four thousand cases" and lost no patient to the agent. He gave it to Queen Victoria. He insisted on a measured vapour of about 4% chloroform in air rather than a soaked cloth (Snow 1858). His results and the general record diverge sharply. The German surgical congress statistics collected by Gurlt from 1890 show the gap:

Period	Administrations	Deaths	Chloroform death rate	Ether death rate
To 1893	163,493	61	about 1 in 2,000 to 2,650	about 1 in 14,600
To 1897	327,593	134	about 1 in 2,039	not recorded here

(Hospital 1897. Dental Register 1895. Both read as secondary summaries [VERIFY].) Every series found shows chloroform killing several times as often as ether. Snow's figure shows that the person giving the drug mattered as much as the drug.

What the record shows: the Hyderabad commissions. The argument about why chloroform killed lasted fifty years. The Nizam of Hyderabad paid for two commissions, the first in 1888 under Surgeon-Major Edward Lawrie, the second in 1889 joined by Thomas Lauder Brunton for the Lancet. Together they killed several hundred dogs, monkeys and other animals. They concluded that chloroform always stops breathing before it stops the heart, so that an administrator who watched only the breathing could prevent every death (Dental Register 1890, metadata only. Nature 1890, secondary). The commission was wrong.

In 1911 Alfred Goodman Levy, working with Thomas Lewis, showed that light chloroform anaesthesia can throw the heart into ventricular fibrillation. He argued that intermittent light chloroform is more dangerous than a deep anaesthetic (RCoA, Levy biography). The dangerous phases are induction and the patient who is coming round and gets another splash. Hannah Greener died in exactly that phase, struggling at the first cut.

What the record shows: delayed poisoning. Leonard Guthrie described liver failure days after chloroform in the 1890s, especially in children and fasting or septic patients (Hospital 1909, metadata only. general-anaesthesia.com, chloroform liver). A 1997 review found clinically significant liver injury rarer than a 1912 American Medical Association committee had feared (Thorpe and Spence 1997, abstract only).

What modern science infers. Chloroform makes the heart prone to arrhythmia, and adrenaline from fear or pain makes this worse. The gap between an anaesthetic dose and a lethal one is narrow. Ralph Waters tried to rehabilitate chloroform with measured vaporisers in the 1940s and failed. It had left clinical practice by the 1970s [VERIFY, secondary summary only].

After the Fall, chloroform is a trap. Quick, smooth and non-flammable, it is the agent most attractive to the untrained and the most likely to kill a frightened young patient without warning. No doses are given here. Treat stored chloroform as a poison, not a reserve anaesthetic.

1.4 Ether by the open drop and the draw-over vaporiser

What the tradition says. Ether is the forgiving anaesthetic. The Update in Anaesthesia article on draw-over technique calls it "certainly the safest volatile anaesthetic in the hands of the inexperienced or occasional anaesthetist" (Dobson, Update in Anaesthesia). It stimulates breathing and keeps up cardiac output. Of the volatile agents, it is the only one that can safely be given to a patient breathing unaided without added oxygen.

What the record shows: the open drop. Ether is dripped onto gauze stretched over a wire frame, the Schimmelbusch mask, held over the nose and mouth.

- A military review gives 4 to 6 layers of gauze and 10 to 15 minutes to reach surgical anaesthesia (JSOM 2018).
- An older account quoted there gives 8 to 10 layers, 10 to 20 minutes for an adult, and 2.5 to 5 fluid ounces of ether to reach surgical depth [single source, VERIFY].
- A British training film, "Open Drop Ether", was made in 1944, and the method is in the 1981 US Special Forces medical handbook (JSOM 2018).

What the record shows: the draw-over vaporiser. It improved on the open drop. The Epstein-Macintosh-Oxford (EMO) vaporiser was introduced in 1956 [VERIFY, secondary summary only].

- A water jacket holds the ether at a steady temperature and a dial is calibrated in per cent.
- The patient's breath, or a self-inflating bag, draws room air through it, so it needs no compressed gas. It works between about 10 and 30 °C (Pescod, Developing Anaesthesia).
- Maintenance in a spontaneously breathing patient is 6 to 8% (Dobson. Pescod).
- With a muscle relaxant and assisted breathing, 3 to 4% is enough (Dobson). After induction under controlled breathing, Pescod gives 4 to 8%.

The EMO became standard in Ugandan district hospitals, where ether long remained the main agent (Mulago ECG study, search record only) [VERIFY].

What the record shows: Guedel's stages. Arthur Guedel published his stages in 1920 and drew his chart in 1937. They were drawn from ether and remain the map for any slow inhaled agent (Wikipedia, "Guedel's classification". JSOM 2018).

- **Stage I, analgesia.** The patient is still conscious.
- **Stage II, excitement.** Breath-holding, struggling, vomiting and laryngospasm are most likely here.
- **Stage III, surgical anaesthesia.** There are four planes. Breathing becomes regular and then shallower, the eyes stop moving and the pupils widen. In the third plane the muscles between the ribs fail and only the diaphragm breathes.
- **Stage IV, overdose.** Breathing stops, the pupils are widely dilated, and the circulation fails after.

"Apnea occurs long before cardiovascular collapse", which is what makes ether forgiving. An operator who watches the breathing has time to act (JSOM 2018).

What the record shows: outcomes. Field series for open-drop ether are few, but the one found is striking. At the Women's Hospital in Kathmandu in 1982 to 1983, 535 caesareans were done among 7,263 deliveries, in mothers with a mean haemoglobin of 86 g/L. With no anaesthetist on call, junior obstetric residents gave over 90% of the anaesthetics by open-drop ether without intubation. Of 420 cases reviewed, 11 women had a chest infection afterwards, none suggesting inhaled stomach contents, and all recovered. Of 18 maternal deaths among all deliveries, one occurred during a caesarean, from haemorrhage, not the anaesthetic.

The authors concluded that "For poor risk patients, and in unskilled hands, diethyl ether remains a remarkably safe anaesthetic" (Maltby, Malla and Dangol 1986, abstract only).

What the record shows: cost. Ether costs a fraction of modern agents. A 2015 review argued for reviving ether and making it locally (Chang et al. 2015):

Agent	Price per litre	Cost per hour of anaesthesia
Halothane	about US$140	US$2.24
Ether	about US$10	US$0.16

The same review gives the context in Uganda. Only 23% of anaesthetists met minimum requirements. Only 16% of government hospitals and 50% of mission hospitals could deliver safe adult anaesthesia.

What the record shows: problems.

- **Slow, unpleasant induction.** Ether alone makes patients cough, hold their breath and salivate. It irritates the larynx and causes vomiting (Dobson). Hence the classic combination: a quick intravenous drug to induce sleep, then ether to keep it.

- **Vomiting afterwards.** Post-operative nausea and vomiting are common [VERIFY, rates found only in secondary summaries].
- **Heat.** Ether boils at about 35 °C. In a hot climate the open drop wastes the agent and becomes hard to control (Pescod. JSOM 2018).

Did MSF and the ICRC keep ether? The brief assumes they did. The record found does not support that for recent decades. The ICRC's 2010 war surgery manual makes ketamine the agent of choice and does not mention ether (Giannou and Baldan 2010). MSF's 19,395 anaesthetics in 2013 used ketamine, thiopental and halothane (Trelles and Teicher 2015). The Zimbabwe series says "Ether is not used in Zimbabwe" (Glenshaw and Madzimbamuto 2005).

Ether lasted longest in mission and government hospitals in Nepal, Uganda and similar places, for its low cost, no need for compressed gas, and safety in inexperienced hands (Chang et al. 2015. Dobson). It declined because of fire, slow induction, vomiting and the arrival of halothane and ketamine, not, on the evidence found, because of deaths.

What modern science infers. Ether's MAC, the concentration at which half of patients stop moving at the incision, is about 1.9%. Its blood/gas solubility is high at 12, so it is slow both to act and to wear off, and 10 to 15% is metabolised (Pescod). High solubility is why ether is safe. The concentration in the brain moves slowly, so an overdose builds over minutes and the operator sees it coming. The same property makes induction a long passage through the dangerous stage II.

1.5 Fire, explosion and peroxide

Fire. Ether vapour is heavier than air and flows along the floor. Its flash point is −45 °C (−49 °F), and it burns at 1.9% to 36% in air (NIOSH Pocket Guide). Its flame is nearly invisible in daylight (JSOM 2018).

The first recorded anaesthetic fire was in 1850, when ether caught fire during an operation on the face. Fires became more destructive once oxygen replaced air as the carrier gas, and many were never reported (MacDonald 1994, abstract only). Around 1960 in the United States, ether fires were estimated at about 1 in 100,000 anaesthetics (Chang et al. 2015).

The draw-over guidance treats everything within 30 cm of the breathing system as a zone of risk, bans diathermy in operations on the head, neck or chest, keeps oxygen and ignition apart in time, and calls for antistatic precautions in dry climates (Dobson).

In air, ether burns but does not explode. Mixed with oxygen or nitrous oxide, it explodes. The ICRC calls oxygen cylinders in a war hospital "the equivalent of a bomb" (Giannou and Baldan 2010).

Peroxide. Ether stored in air and light forms organic peroxides. These can detonate when a container is opened or when ether is evaporated to dryness (NIOSH Pocket Guide). University safety guidance gives these shelf lives (University of Michigan-Dearborn EHS):

- stabilised ether, unopened: about two years
- stabilised ether, opened: about one year
- ether without stabiliser: dangerous peroxides in under two weeks.

A container with crystals around the cap or in the liquid must not be opened or moved by an untrained person.

Purity. Peroxides and acetaldehyde are also poisons to the patient. A Korean review found that contaminated anaesthetic ether caused salivation, bronchial secretions, fluid in the lungs and pneumonia. It quoted early advice not to use ether more than 24 hours after a can was opened, although later studies found sealed cans stayed acceptable for months (Yonsei 1973, abstract only). In 1929 US authorities seized anaesthetic ether that contained peroxide (NLM, FDA notice of judgment).

Ether is therefore a perishable drug in a dangerous container. Storage rules are in 11.6.

1.6 Nitrous oxide

What the tradition says. Laughing gas founded painless dentistry. In modern practice a 50:50 mixture with oxygen is widely used to relieve pain in labour and during short procedures [VERIFY, no source read in this research].

What the record shows.

- **It is weak.** Its MAC is about 104%, more than the whole atmosphere. It cannot produce surgical anaesthesia on its own without starving the patient of oxygen (Pescod). Early dental use relied on short administrations that came close to asphyxia [VERIFY].
- **It expands closed air spaces.** At 70% it doubles the size of a pneumothorax in about 10 minutes (Pescod).
- **It causes diffusion hypoxia.** When the gas is stopped it floods out of the blood into the lungs and dilutes the oxygen there (Pescod).
- **It needs cylinders, regulators and oxygen, and it feeds fire.** It turns ether from flammable into explosive (Dobson).

The manufacturing record is a warning. In 1967 two patients in Britain were poisoned when nitrous oxide had been contaminated during manufacture with higher oxides of nitrogen (Clutton-Brock 1967, abstract and secondary only). Those oxides cause laryngospasm, methaemoglobinaemia and fluid in the lungs [secondary, VERIFY].

What modern science infers. Nitrous oxide belongs to an industrial world. A community after the Fall can salvage it in cylinders for dentistry and labour, but it is not a route to surgical anaesthesia. Making it carries a risk of contamination that only gas analysis can detect. It ranks last of the four agents here.

1.7 Rectal and intravenous routes

What the tradition says. Rectal and intravenous routes were promoted as gentler than the mask, free of the struggle of stage II.

What the record shows. Pirogov's rectal ether (1.2) had successors. From 1913 James Gwathmey promoted an oil and ether mixture by the rectum and claimed about 20,000 obstetric cases by 1930. It caused deaths and burns of the bowel and was abandoned, a case of technique outpacing evidence (CSA 2026). Ludwig Burkhardt gave 5% ether in saline into a vein in 1909. Stronger solutions destroyed red cells and inflamed the veins (general-anaesthesia.com, intravenous ether) [VERIFY]. Avertin (tribromoethanol) was given by the rectum from 1926 to 1927 at up to 0.1 g/kg. Given into a vein by Kirschner, it inflamed the veins of 3% of patients and killed one by embolism (ai-online 2017) [secondary, VERIFY].

What modern science infers. A drug given by rectum or vein cannot be taken back, whereas an inhaled agent leaves when the mask is lifted. Ketamine is safe enough for this only because its margin is wide. MSF also allows rectal ketamine at the IM dose (Trelles and Teicher 2015). None of the historical rectal methods should be revived.

1.8 Ketamine, the salvage drug

What the tradition says. Calvin Stevens made ketamine at Parke-Davis in 1962. Edward Domino named it a "dissociative anaesthetic" in 1965. It was patented in 1966 and used in Vietnam (Stevenson, Update in Anaesthesia 20). It is the anaesthetic of the world's poorest operating theatres.

It has been on the WHO Essential Medicines List since 1985. In 2015 a WHO expert committee advised, for the fourth time since 2006, against international control, because in large areas it is the only anaesthetic (Pharmaceutical Journal 2016).

What the record shows: why it is the salvage drug.

- It keeps blood pressure up.
- It usually preserves breathing and some tone in the airway.
- It needs minimal equipment, not even an oxygen concentrator. For this reason the ICRC makes it the agent of choice for major war surgery (Giannou and Baldan 2010).
- Apnoea is unusual unless it is given rapidly or with an opioid. Aspiration remains a hazard (Stevenson).
- It can be given into a muscle when no vein can be found.

Doses. Each dose below is taken from at least two sources. Where they differ, the difference is noted.

Use	Stevenson (MSF review)	MSF Essential Drugs	Trelles and Teicher (MSF)	Product information (Ketalar)	ICRC (Giannou and Baldan)
IV induction	1 to 2 mg/kg in increments, onset 1 to 2 min, lasts about 10 min	2 mg/kg slowly, onset about 1 min, lasts 10 to 15 min	1 to 2 mg/kg, onset 1 to 2 min, lasts 10 to 15 min	1 to 4.5 mg/kg, average 2 mg/kg, over 60 s	very slowly over 1 min, incision after about 1 min
IM induction	6 to 8 mg/kg, onset 5 to 10 min	8 to 10 mg/kg, onset 5 min, lasts 15 to 30 min	8 to 10 mg/kg, lasts 20 to 30 min	6.5 to 13 mg/kg, 10 mg/kg lasts 12 to 25 min	onset 5 to 10 min
IV top-up	0.5 mg/kg every 15 to 20 min	0.5 to 1 mg/kg about every 15 min	0.5 to 1 mg/kg every 15 to 20 min	half to the full induction dose	one third to one half of the induction dose at 10 to 15 min
IM top-up	5 mg/kg every 30 min	5 mg/kg every 20 to 30 min	5 mg/kg every 20 to 30 min	not read	not read
Analgesia only	0.5 mg/kg IV, 2 to 4 mg/kg IM	not read	0.3 to 0.8 mg/kg IV, 2 to 4 mg/kg IM	not read	0.1 to 0.3 mg/kg IV, 2 to 3 mg/kg IM

All sources agree on about 2 mg/kg IV over at least a minute and 6 to 10 mg/kg IM. The ICRC warns that rapid IV injection can stop breathing. The product information allows higher doses and larger top-ups than humanitarian practice. For analgesia the IV doses differ two- to threefold, so start at the low end.

Infusion.

- Stevenson: 500 mg in 500 ml (1 mg/ml), at 2 to 4 mg/kg per hour. That is about 1 drop per kg per minute for a patient breathing unaided, or 0.5 drop per kg per minute with controlled breathing. Stop about 30 minutes before the end of the operation.
- Dobson: 1,000 mg in 500 ml (2 mg/ml). About 120 mg to induce, then about 2 mg per minute.
- My arithmetic: at 20 drops per ml [VERIFY], 1 drop per kg per minute of 1 mg/ml is 3 mg/kg per hour, inside Stevenson's range.

The ICRC prefers infusion (Giannou and Baldan 2010).

Caesarean section. Give no more than 1 mg/kg IV. At 2 mg/kg the baby is born depressed (Stevenson. MSF Essential Drugs).

Drugs given with ketamine.

- **Atropine** dries secretions. Stevenson gives 10 to 20 micrograms/kg. The ICRC gives atropine first as routine. The ICRC dose was not found in the text read.
- **Diazepam** reduces emergence reactions. Stevenson gives 0.1 to 0.2 mg/kg, 7 to 14 mg at 70 kg. The ICRC gives 10 mg IV at least 5 minutes before induction and 10 mg IM at the end (Giannou and Baldan 2010). Murambinda gave 10 mg routinely (Glenshaw and Madzimbamuto 2005). The sources agree.

When to avoid ketamine. Relative contraindications are psychosis, severe high blood pressure, pre-eclampsia or eclampsia, ischaemic heart disease, severe mitral or aortic stenosis, an overactive thyroid, epilepsy, an open eye injury and porphyria (Stevenson. Giannou and Baldan 2010. MSF Essential Drugs). The ICRC no longer treats head injury as a reason to avoid it.

Storage and shelf life. MSF says store below 25 °C, protect from light, do not freeze, and discard opened vials. The product information says below 30 °C and protected from light, and requires the 100 mg/ml strength to be diluted before IV use. Ketamine 50 mg/ml in syringes stayed stable for 180 days at 25 °C (Huvelle 2016) [secondary, VERIFY]. The US Shelf Life Extension Program extended 88% of 3,005 lots of 122 drugs by at least a year, though some failed (Lyon et al. 2006, abstract). No data were found on ketamine ampoules years past expiry, so the library's claim of "years unopened" stays [VERIFY].

Harms in the record. Green and colleagues pooled 8,282 ketamine sedations of children in emergency departments (Green et al. 2009a, 2009b, abstracts):

Event	Rate
Airway and breathing events	3.9%
Laryngospasm	0.3%
Vomiting	8.4%
Clinically important agitation on waking	1.4%

Airway events were more likely under age 2, from age 13, with high IV doses (initial 2.5 mg/kg or more, or total 5 mg/kg or more), and, unexpectedly, when atropine or a benzodiazepine was also given.

A later meta-analysis also found ketamine among the drugs linked to laryngospasm in children (Bellolio et al. 2016) [abstract, VERIFY].

Emergence reactions (vivid dreams, hallucinations, agitation) occur in about 12% of adults, less often in children, the elderly and after IM use, and can recur up to 24 hours later. Overdoses of up to ten times the usual dose have ended in prolonged but complete recovery (Ketalar PI). A 2012 editorial warned that preserved airway reflexes are little researched, that throat tone does not prevent aspiration, and that ketamine's saliva on an intact larynx can trigger laryngospasm (Anesthesiology 2012, secondary).

Ketamine in untrained hands: the evidence. This is the central question for the book.

- **Kenya, ESM-Ketamine, children.** A five-day hands-on course trained 28 non-anaesthetist providers. They worked with a checklist, a wall chart, a bag-valve-mask and a pulse oximeter. They gave 2 mg/kg over 30 to 60 seconds and added 0.5 mg/kg as needed. In 90 procedures on 77 children the median dose was 2.0 mg/kg (range 1.4 to 8.3). There were no serious adverse events and no laryngospasm. Minor events occurred in 17%: hallucinations 9, salivation 4, brief desaturation 2 (Schwartz et al. 2016).
- **Kenya, 15 facilities, 2013 to 2017.** Mid-level providers used the package for 1,216 operations, median dose 2.1 mg/kg. Desaturation under 30 seconds occurred in 39 patients (3%), longer desaturation in 7 (0.6%), and hallucinations or agitation needing diazepam in 157 (13%). All recovered, and no ketamine deaths were reported (Burke et al. 2017).

- **Kenya, caesareans.** In 401 emergency caesareans by 54 providers, every mother survived to discharge (Burke et al. 2022).
- **Bangladesh.** A mission hospital at Cox's Bazar reported about 8,000 patients over 15 years under ketamine, largely given by non-specialists, with one anaesthetic death (Ketcham 1990) [figures from a secondary summary, VERIFY].
- **Zimbabwe.** Murambinda mission hospital has 120 beds and serves 250,000 people (Glenshaw and Madzimbamuto 2005).
  - It gave 2,410 anaesthetics from 1994 to 2001, about 300 a year. 794 (33%) were ketamine general anaesthetics and 1,230 (51%) were spinals.
  - The doctor gave IV ketamine and then scrubbed to operate. A nurse watched the patient and gave top-ups of half the loading dose. There was no intubation, and oxygen was given by face mask.
  - Seven patients died within 24 hours, all emergency obstetric cases. Anaesthesia-associated mortality was 1 in 344 overall and 1 in 482 for avoidable deaths.
  - Four of the five anaesthetic deaths followed spinal anaesthesia with low blood pressure. One pre-eclamptic woman given ketamine never regained consciousness.
  - For comparison, the authors cite 1 in 504 in Malawi and 1 in 67,000 in Australia.
- **MSF.** In 2013 MSF-Belgium recorded 44 deaths related to surgery in 19,395 operations (0.2%). Its guidance requires that "Projects that use ketamine must have resuscitation material available, due to the known risk of respiratory arrest" (Trelles and Teicher 2015).
- **Nepal.** Paediatricians gave ketamine for 679 eye operations. They checked breathing with a chin lift and by feeling the breath on the palm (Stevenson).

What modern science infers. Ketamine is the nearest thing to an anaesthetic that a trained non-specialist can give safely, provided three conditions hold:

1. It is injected slowly into a vein or given into a muscle.
2. One person's only job is the airway.
3. A bag-valve-mask and suction are within reach.

Anaesthetists have published criticisms of the Kenya programme (Section 6).

1.9 Making them: who managed, under what conditions, at what cost

The brief asks whether ether could be made at a district infirmary. This section answers from history. It gives no method, by design.

Ether: the history. Valerius Cordus described "sweet oil of vitriol" in 1540. It was published after his death, around 1561. August Sigmund Frobenius named it ether in 1730. One secondary source says Paracelsus had noticed that it put chickens to sleep (Wikipedia, "Valerius Cordus". Encyclopedia.com, ether) [VERIFY]. So the chemistry is old and simple in principle. The hard part is doing it safely and getting a product fit to breathe. Three records show the cost.

- **Squibb's fire.** Edward Robinson Squibb, a US Navy surgeon, designed a steam-heated ether still in 1854. He published it in the American Journal of Pharmacy in 1856 instead of patenting it. He opened his own laboratory in Brooklyn in 1858, and less than a month later, on 24 December 1858, it burned in an ether fire. Squibb was badly burned (Wikipedia, "E. R. Squibb". Civil War Medicine museum, Squibb story). He was the most careful ether maker in America.
- **The Confederacy under blockade.** Cut off from imports, it set up medical laboratories at Lincolnton (from August 1863), Columbia, Macon, Augusta and Tyler, which made ether, chloroform and opiates (Hasegawa and Hambrecht, abstract only. NC Department of Natural and Cultural Resources 2024). They had trained pharmacists and state funding. No figures were found on their output, purity or injuries.

- **Industry also failed.** In 1929 US authorities seized contaminated anaesthetic ether that an industrial maker had produced. Lung damage from impure ether was still a recognised problem into the 1970s (Yonsei 1973. NLM, FDA notice of judgment).

Chang and colleagues argued in 2015 for making ether locally in low-income countries. They meant a pharmaceutical plant with quality control, not a district workshop (Chang et al. 2015).

What a safe supply would need. I infer these requirements from the record above, not from any production source [inference, VERIFY]:

- a reliable supply of the starting chemicals, at least one of which needs a chemical industry to produce
- a building that can be kept apart from all flame and spark
- a person trained in chemistry
- a way to test each batch for peroxide, aldehyde and acid
- sealed, light-proof storage
- a hospital able to tell when a patient's lung injury came from the ether.

A district infirmary of 3,000 in the first decade after the Fall will rarely have all of these. The likely failures are a fire that kills the maker or burns the building, and an impure product that gives patients pneumonia.

Chloroform, nitrous oxide and ketamine. Chloroform is not recommended at any rung (1.3), so its production is not discussed. Nitrous oxide needs industrial manufacture, compression and cylinders, and faulty manufacture in 1967 poisoned patients (Clutton-Brock 1967). Ketamine is a modern pharmaceutical that no rung of the ledger can make. Its supply after the Fall is salvage only, from hospital, veterinary and military stocks. Veterinary ketamine often comes at 100 mg/ml, and by the product information's rule it must be diluted before it goes into a vein [inference, VERIFY].

The risk of the account itself. Would a production account attract readers who should not attempt it? My judgement is yes. Ether is also used in making illicit drugs and is a fire hazard for any amateur. A recipe in a novel would be copied by curious readers, and the realistic result is burns, not anaesthesia.

The book can tell the truth about Squibb's fire and the Confederate laboratories, and can show a chemist with a still and the consequences, without giving a method. That is also historically honest: the obstacle was never the recipe. It was the acid, the testing and the fire.

1.10 What every agent needs: airway, oxygen, monitoring and a trained second person

In poor settings, deaths under anaesthesia come mostly from lack of oxygen, inhaled vomit, a blocked airway and bleeding, rarely from the drug's chemistry.

Monitoring. Lifebox reports that pulse oximetry, which detects falling oxygen before the colour changes, was available in only 41 to 70% of operating environments in low- and middle-income countries [secondary, VERIFY]. Clinical signs of low oxygen are late and unreliable, especially in dark skin and in anaemic patients. Salvaged fingertip oximeters and their batteries are among the most valuable things a district can store.

Oxygen. A concentrator gives about 4 L/min at over 90% purity on about 350 W. Added to a draw-over system, 1 L/min raises inspired oxygen to 30 to 40%, and 4 L/min to 60 to 80% (Dobson). Ketamine and ether can both be given in air, but every resuscitation is easier with oxygen.

Training and the second person. At Murambinda, patients resuscitated by the physician anaesthetist mostly survived (4 of 5). Those resuscitated by clinical officers mostly died (9 of 10) (Glenshaw and Madzimbamuto 2005). The skill that saves the patient is rescuing the airway. The Kenya programme showed it can be taught in days with a manikin and a bag.

2. Evidence grades

Grades: A means strong modern evidence (controlled trials or very large series). B means consistent observational series. C means case series, expert guidance or historical statistics. D means anecdote or a single report. X means evidence of harm: do not use.

Claim	Grade	Basis
Ketamine at about 2 mg/kg IV given slowly, or 6 to 10 mg/kg IM, gives 10 to 30 minutes of surgical anaesthesia	B	Product information, MSF, ICRC, Kenya series
Trained non-anaesthetists can give ketamine with low rates of serious events	B	Kenya series of 1,216 and 401, Zimbabwe, Bangladesh. No controlled trial
Rapid IV ketamine can stop breathing	B	ICRC, MSF, product information
Ketamine protects the airway against aspiration	C, disputed	2012 editorial. Vomiting in 8.4% of children
Open-drop ether is safe in unskilled hands for poor-risk patients	C	Kathmandu series, Dobson, Chang
Under ether, breathing stops before the heart, giving warning	C	Guedel, JSOM review, clinical teaching
Chloroform killed several times as often as ether	B (historical)	Gurlt statistics, Levy
Chloroform as an anaesthetic after the Fall	X	Arrhythmic death in light anaesthesia, liver injury
Rectal ether, rectal or IV Avertin, IV ether	X	Deaths, bowel burns, inflamed veins, embolism
Nitrous oxide alone for surgery	X	MAC above 100%
Locally made ether is safe to breathe	D	No series found on the outcomes of improvised ether
Ketamine keeps its potency well past expiry	D	No direct data. Indirect evidence from the Shelf Life Extension Program
Spinal anaesthesia is safer than ketamine at a district hospital	Not shown	At Murambinda most anaesthetic deaths followed spinals (see WO-11)

3. Means ledger

Rung	What sleep is possible	What it needs	Who has managed it	Failure and injury to expect
Hands	None. Holding, positioning, speed, pressure, and the non-drug methods in WO-11	Hands, helpers, the airway skills of chin lift, jaw thrust, recovery position and clearing the mouth	All surgery before 1846	Pain, shock, struggling, and only short operations possible

Rung	What sleep is possible	What it needs	Who has managed it	Failure and injury to expect
Hearth	None. Alcohol and opium dull pain but are not anaesthesia (see other library reports)	Spirit and opium	Pre-1846 surgeons	A drunk patient lying on his back who vomits can inhale it [inference]
Garden and still	None safely. A still makes strong alcohol. Ether needs an acid supply, testing and a building free of flame (1.9)	Not achievable safely at this rung	Cordus as a curiosity, 1540. Squibb as an expert, who was burned in 1858	No outcome series exists. Expect fire and impure product. Do not attempt
Village dispensary of 300	Salvaged ketamine IM or IV for short procedures. Salvaged ether by open drop in exceptional cases	A trained giver plus a second person on the airway, bag-valve-mask, suction (bulb or foot pump), atropine, diazepam, an oximeter if possible, Schimmelbusch mask and sealed ether tins for ether	Kenya mid-level providers. Nepal paediatricians. Kathmandu residents with ether	Emergence reactions about 10 to 13%. Vomiting about 8%. Laryngospasm about 0.3% in children. Brief desaturation about 3%
District infirmary of 3,000	A ketamine service with IV infusion for long operations. Spinal anaesthesia (WO-11). Draw-over ether if a vaporiser and ether are salvaged	Protocol, checklist and wall chart, five days of training, oxygen concentrator and electricity (about 350 W), oximeters, a recovery area, ephedrine or another vasopressor for spinals	Murambinda mission hospital. ICRC and MSF field hospitals. Ugandan district hospitals with the EMO	Anaesthesia-associated mortality of about 1 in 350 to 1 in 500, concentrated in emergency obstetrics (Glenshaw and Madzimbamuto 2005). No ether production in the first decade [inference]
Hospital reference	Intubation, muscle relaxants, modern volatile agents, full monitoring	An industrial supply chain and specialists	Modern health systems	About 1 in 67,000 in Australia. In the US in 1948 to 1952, 1 death primarily from anaesthesia in 1,560 (Beecher and Todd 1954)

4. Harm test

Each option is set against the five harms the brief names: overdose, lost airway, fire, aspiration and the patient who wakes. The comparison is with operating without anaesthesia, or not operating at all (THRIVING library, WO-08).

Ketamine.

Harm	Risk and what to do
Overdose	Wide margin. Even tenfold overdoses have ended in prolonged but complete recovery (Ketalar PI). The real danger is speed: rapid IV injection can stop breathing. Give it over 60 seconds or more
Lost airway	Laryngospasm about 0.3% in children. Airway and breathing events 3.9% (Green et al. 2009a)
Fire	None, unless oxygen cylinders are used carelessly
Aspiration	Vomiting 8.4% in children. Reflexes are not reliably preserved (Anesthesiology 2012). Use a lateral position on recovery and keep suction ready
The patient who wakes	Too light: top up. Emergence reactions about 12% of adults, treat with diazepam
Verdict	Benefit clearly outweighs harm for operations that cannot wait, when a second person, a bag-mask and suction are present

Open-drop or draw-over ether.

Harm	Risk and what to do
Overdose	Slow, visible build-up. Breathing becomes shallow and diaphragmatic, the pupils widen, then breathing stops. Lift the mask, support breathing, and the patient breathes the ether out
Lost airway	Laryngospasm and breath-holding are common in stage II. Use a chin lift or jaw thrust and an oral airway [VERIFY]
Fire	Real. Rare in air, explosive with oxygen. No flame or spark within 30 cm. No electric cautery near the head
Aspiration	Vomiting is common at induction and afterwards. In the Kathmandu series, 11 chest infections in 420 caesareans, none attributed to aspiration
The patient who wakes	Slow to lighten, so sudden waking is unusual
Verdict	Acceptable with salvaged, sealed ether and a trained giver. Not acceptable with ether of unknown origin or with any open flame in the building

Fails the harm test. Chloroform (sudden cardiac death in light anaesthesia, about 1 in 2,000 historically, and liver injury). Nitrous oxide for surgery (too weak, diffusion hypoxia, lethal if contaminated, so analgesia from intact commercial cylinders only). Locally made ether (fire for the maker, lung injury from contaminants, no test without chemistry).

5. Red flags

Stop, call for help and act at once if any of these appear.

During ketamine:

- A crowing or high-pitched noise on breathing in, or effort to breathe with no air moving. This is laryngospasm or obstruction.
- Gurgling: saliva or vomit in the throat. Suction now.
- An oximeter reading below 90%, or blue lips. Blue lips are a late sign.
- Breathing stops after an IV dose. The dose was too fast or too large. Support breathing with the bag.
- Rising pressure or fits in a pre-eclamptic woman. Avoid ketamine in pre-eclampsia, and remember the Murambinda death.

During ether:

- Breathing becomes shallow, the chest stops moving and only the belly moves.
- The pupils widen and stay wide.
- Breathing stops: stage IV. Lift the mask and breathe for the patient.
- You can smell ether near any flame, stove, lamp or spark.
- There are crystals around the cap of an ether tin. Do not open or move it.

At any point:

- The patient moves or cries at the incision. They are too light. With chloroform this was the phase of sudden death. With ketamine, top up.
- After the operation, the patient has not woken within two hours [VERIFY, threshold is my inference]. Or they vomit while lying on their back. Or hallucinations return after they have woken.

6. The case against (critics named)

Against ketamine in untrained hands. D. Cheng, G. Barreiro, F. Khan and J. Mellin-Olsen, writing for the World Federation of Societies of Anaesthesiologists, commented on the Kenya programme in 2018. L. Litswa, for the Kenya Society of Anaesthesiologists, also wrote a letter (Cheng et al. 2018. Litswa 2018). Their content was not read. I infer that their likely concerns are these [inference, VERIFY]:

- task-sharing without an anaesthetist's supervision
- under-reporting of adverse events in series reported by the programme itself
- the absence of a comparison group.

The evidence base is indeed made of uncontrolled series by enthusiasts.

Against the safety of ketamine's airway. The 2012 Anesthesiology editorial argued that the preservation of airway reflexes is assumed, not proven (Anesthesiology 2012). Green's data from well-equipped emergency departments still show 3.9% airway events in children.

Against ether. Glenshaw and Madzimbamuto report a country that had abandoned ether altogether. Fire, slow induction, vomiting and failure in heat are real, and MacDonald notes that many fires were never reported.

Against the historical statistics. Snow's 4,000 chloroform cases without a death show that the skill of the person giving the drug may matter more than the agent. Edward Lawrie and the Hyderabad commissions show how a confident, well-funded consensus can be wrong and keep killing patients for twenty years, until Levy's 1911 work.

Against Chang's case for reviving ether. It assumes pharmaceutical-grade production. Contamination and Squibb's fire show cheap ether is safe only when made well.

Against this report. The good ketamine figures come from programmes that had training, oximeters, supervision, selected patients and research funding. After the Fall none of these is assured, so real complication rates will be higher [inference]. The Kathmandu ether series survives only as an abstract, and its mortality data concern the mothers, not anaesthetic morbidity in detail.

7. 10-line summary

1. Every anaesthetic kills by the same routes: stopped breathing, blocked airway, aspiration, heart failure, fire and early waking.
2. Ketamine is the salvage drug. Give 2 mg/kg IV over at least a minute, or 6 to 10 mg/kg IM.
3. With training, a checklist, a bag-mask and an oximeter, Kenyan non-anaesthetists gave it for 1,216 operations with no deaths.
4. Ether is the forgiving inhaled agent: breathing fails before the heart, so a watcher has warning.
5. Junior residents in Kathmandu gave open-drop ether without intubation for over 90% of caesareans and lost no mother to the anaesthetic.
6. Ether burns with an almost invisible flame, explodes with oxygen, and forms peroxides in storage.
7. Chloroform killed several times as often as ether, often young patients in light anaesthesia. Do not use it.
8. Nitrous oxide is too weak to anaesthetise alone and is dangerous if made badly.
9. Making ether safely needs an acid industry, testing and a flame-free building. Squibb, the expert, burned. A district should salvage, not make.
10. The decisive skill is the airway, held by a second trained person with suction and a bag.

8. Open questions

1. How long does ketamine in sealed ampoules keep its potency past its expiry date, at 25 °C and at 35 °C? No data were found.
2. What did Cheng et al. and Litswa actually argue against the Kenya programme, and did the reply answer it?
3. Is there any field series of open-drop ether mortality beyond Kathmandu, especially from Uganda, India or Nigeria in the 1960s to 1980s? A search found none.
4. What output, purity and injury record did the Confederate medical laboratories have?
5. What are the full texts of the Hyderabad commission reports? Only metadata and summaries were seen.
6. What dose of atropine does the ICRC use before ketamine? The table in the manual read did not print it.
7. Can a district train an airway assistant in five days to the standard Kenya reports, without a research team?
8. Does spinal anaesthesia or ketamine give the lower death rate for emergency caesarean at a district without vasopressors? WO-11 should address this.

9. Sources to read in full

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7. Glenshaw M and Madzimbamuto FD (2005). A model district audit, read in full.
8. Burke TF et al. (2017) and the three replies in World Journal of Surgery (2018).
9. Fenster JM, *Ether Day* (2001). Not seen.
10. MacDonald AG (1994), fires and explosions. Abstract only read.

10. At the bedside after the Fall

Household.

- *What is possible:* no general anaesthesia. Stop bleeding, splint, keep warm, and get the patient to the dispensary.
- *What it needs to start:* someone who knows the recovery position, chin lift and jaw thrust, and gives no alcohol or opium to a patient who may need surgery [inference].
- *First failure to expect:* spirits given for pain, then vomit inhaled by a patient lying on their back.

Village of 300.

- *What is possible:* short procedures under salvaged ketamine, usually IM, sometimes slow IV. Examples are reducing a dislocation or fracture, cleaning and debriding a wound, draining an abscess, and manual removal of a placenta when no one can be moved. Open-drop ether only if sealed tins and a Schimmelbusch mask exist, out of doors or in a large room with no flame.
- *What it needs to start:* two trained people (one gives the drug and watches the airway, one operates), a dose chart by weight, a bag-valve-mask, suction (a bulb syringe at minimum), atropine and diazepam, a fingertip oximeter if salvaged, and someone to sit with the patient until awake.
- *First failure to expect:* a hallucinating, agitated patient on waking, frightening the family and the village. Then a vomit and gurgle while the giver is helping the surgeon instead of watching the airway.

District of 3,000.

- *What is possible:*
  - ketamine general anaesthesia, by infusion for long cases, for laparotomy, caesarean, amputation and burns surgery
  - spinal anaesthesia (WO-11)
  - draw-over ether if an EMO or similar vaporiser and stocks of ether survive.
- *What it needs to start:* a designated anaesthetist and deputy trained on a five-day course of the Kenya model with a manikin, a checklist on the wall, an oxygen concentrator and the 350 W to run it, oximeters, a recovery room, an audit book of every anaesthetic and death as Murambinda kept, a fire rule if ether is used, and a stock register for ketamine, ether and oxygen.
- *First failure to expect:* a death in an emergency obstetric case. It will come either from low blood pressure after a spinal or from a pre-eclamptic woman given ketamine, the pattern at Murambinda. The second failure is running out of ketamine, which is why stock must be counted from the first day.

11. Protocols

These checklists are drawn from the sources cited. Any figure not found in two sources is marked. They assume salvaged commercial drugs only.

11.1 Before any anaesthetic

1. Confirm the operation cannot wait or be done under local anaesthesia (WO-11).
2. Weigh the patient, or estimate the weight. Write it down.
3. Ask when they last ate. Six hours without food is the usual aim [VERIFY, not sourced in this research]. If they are not fasted and the operation cannot wait, plan for vomiting: suction ready, head-down tilt possible, lateral position on recovery.
4. Check for pre-eclampsia, severe high blood pressure, heart disease, psychosis and eye injury. If present, consider spinal or local anaesthesia instead of ketamine.
5. Set out a checked bag-valve-mask, working suction, an oral airway, oxygen if available, the oximeter switched on, and drawn-up, labelled drugs.

6. Name the airway person. They do nothing else.
7. Put in an IV cannula if possible. Even for IM ketamine, a vein is needed for diazepam and fluids.

11.2 Ketamine IM for a short procedure (village)

1. Atropine 10 to 20 micrograms/kg IM or IV (Stevenson). For 60 kg, that is 0.6 to 1.2 mg.
2. Diazepam 0.1 to 0.2 mg/kg IV if a vein is in, or 10 mg for an adult (Stevenson. Giannou and Baldan 2010). It can be given at the end instead.
3. Ketamine 6 to 10 mg/kg IM into a large muscle (Stevenson 6 to 8. MSF and Trelles 8 to 10). Start at 8 mg/kg for an adult. For 60 kg, 480 mg is 9.6 ml of 50 mg/ml.
4. Wait 5 to 10 minutes. Test with a pinch before cutting.
5. Duration is about 15 to 30 minutes. If more time is needed, give 5 mg/kg IM every 20 to 30 minutes (MSF Essential Drugs. Trelles and Teicher 2015).
6. Throughout, keep the chin lifted, watch the chest move, feel the breath on your palm and read the oximeter (Stevenson).
7. Recover the patient on their side, in a quiet place, with someone watching until they speak sensibly.

11.3 Ketamine IV for a major operation (district)

1. Do steps 1 and 2 of 11.2. The ICRC gives diazepam 10 mg IV at least 5 minutes before induction.
2. Induction: 1 to 2 mg/kg IV over at least 60 seconds. One way is 30 mg every 60 seconds, up to about 100 mg in a 70 kg man (Stevenson. Ketalar PI. Giannou and Baldan 2010). For caesarean, give no more than 1 mg/kg before delivery (Stevenson. MSF Essential Drugs).
3. The incision can start after about 1 minute.
4. Maintenance by bolus: 0.5 mg/kg IV every 15 to 20 minutes, or sooner if the patient moves (Stevenson). The ICRC gives one third to one half of the induction dose at 10 to 15 minutes.
5. Or maintenance by infusion: 500 mg in 500 ml (1 mg/ml) at 2 to 4 mg/kg per hour, about 1 drop per kg per minute with a 20 drop/ml set (Stevenson) [drop factor VERIFY]. Stop about 30 minutes before the end.
6. Diazepam 10 mg IM or IV at the end (Giannou and Baldan 2010).
7. Have a nurse record pulse, breathing and oxygen saturation every 5 minutes [interval is my inference].

11.4 Open-drop ether with salvaged ether

Use this only if ketamine is unavailable or unsuitable, the ether is from a sealed, in-date or recently opened tin without crystals, and there is no flame in the building.

1. Do step 1 of 11.2 (atropine) to reduce salivation.
2. Use a Schimmelbusch mask covered with 4 to 6 layers of gauze (JSOM 2018), with a towel around the edge.
3. Drip slowly at first, increasing as the patient tolerates it. No drip rate was found in a source read [VERIFY]. Speak calmly. Expect coughing and breath-holding in stage II, and do not hurry it.
4. Surgical depth arrives in 10 to 20 minutes. Signs are regular breathing, no eyelash reflex, the eyes still and centred, and no response to a pinch (JSOM 2018. Guedel).
5. Too deep: breathing shallow and diaphragmatic only, or pupils widening. Lift the mask and stop dripping. If breathing stops, ventilate with the bag on air.
6. Keep everything electrical and every flame away. Remember the vapour is heavier than air and pools on the floor.
7. Expect vomiting on waking. Recover the patient on their side.

11.5 If the airway is lost

1. Stop the operation and all stimulation.

2. Lift the chin and thrust the jaw forward.
3. Suction the mouth and throat.
4. Put in an oral airway if the patient tolerates it [VERIFY].
5. Seal the mask tightly and squeeze the bag firmly. Steady positive pressure often breaks laryngospasm [VERIFY, standard teaching not sourced in this research].
6. Give oxygen if available.
7. If on ether, remove the mask from the ether source and ventilate with air.
8. If ketamine was just given fast, keep ventilating. The breathing usually returns within minutes [inference, VERIFY].

11.6 Storing the drugs

- **Ketamine:** below 25 °C, dark, not frozen. Discard opened vials (MSF Essential Drugs). Count stock weekly.
- **Ether:** sealed tins or amber glass, cool, dark, away from all flame, and never on a high shelf above a stove. Do not open a tin with crystals around the cap. Use stabilised ether within about a year of opening (University of Michigan-Dearborn EHS).
- **Oxygen cylinders:** stored and moved as explosives (Giannou and Baldan 2010).

12. Numbers to carry

1. **Ketamine IV:** about 2 mg/kg given over at least 60 seconds. **Ketamine IM:** 6 to 10 mg/kg.
2. **Top-ups:** IV 0.5 mg/kg every 15 minutes, or IM 5 mg/kg every 20 to 30 minutes.
3. **Caesarean:** no more than 1 mg/kg IV ketamine before delivery.
4. **Atropine** 10 to 20 micrograms/kg. **Diazepam** 0.1 to 0.2 mg/kg, about 10 mg for an adult.
5. **Ether in air:** burns between 1.9% and 36%. The zone of risk is 30 cm. It explodes with oxygen.
6. **Draw-over ether for maintenance:** 6 to 8% with the patient breathing unaided.
7. **Chloroform:** about 1 death in 2,000 administrations, against ether at about 1 in 14,600 (Gurlt).
8. **Kenya ketamine programme:** 1,216 operations, 0.6% prolonged desaturation, 13% hallucinations, no ketamine deaths.
9. **Murambinda:** 1 anaesthesia-associated death in 344, almost all in emergency obstetrics and most after spinals.
10. **An oxygen concentrator** gives about 4 L/min on about 350 W.

13. References

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