Accidental Admixing of Compressed Air to Oxygen

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(Key words: pipe-lines, gases, nitrous oxide, hypoxia)

Many cases of hypoxia caused by failure of anesthesia machines or bulk oxygen delivery system have been reported[1,2], but anesthesiologist must fully rely on them during the perioperative period. When an accident suddenly occures, anesthesiologist may the temporarily baffled, and serious irreversible consequences may result.

This is such a report describing a sudden and transient decrease of oxygen concentration in the central oxygen supply system which we recently experienced. Retrospective analysis revealed that the cause was due to a faulty construction in the bulk oxygen delivery system.

Course of the Accident

On June 18, 1985, at about 3:35 p.m. the oxygen concentration alarms (Hama Ika, Japan) of four anesthesia machines sounded simultaneously. The oxygen concentration in the anesthesia circuit, as indicated by a digital display on the monitors were 8%, 16% and 17%, respectively. The gas flows of all four machines were nitrous oxide 4 l/min and oxygen 2 l/min. In two of these cases, nitrous oxide was discontinued immediately after the alarm and cyanosis was not observed. In another patient undergoing Miles' procedure, the arterial blood pressure had decreased from 92/58 to 62/42 mmHg, and the oxygen concentration displayed on digital monitor was 17% when the alarm sounded. There was mild but definite cyanosis in the face and finger nail of patient. Nitrous oxide and oxygen flows were immediately readjusted to 3 l/min of each. As a result, cyanosis diasppeared within a minute. In the fourth patient undergoing eye surgery in a dark room, the anesthesiologist noticed the decrease of blood pressure from 88/56 to 54/32 mmHg, and the oxygen concentration was only 8% when alarm rang, but severe cyanosis could not recognized until the room lights were turned on. Following the discontinuation of nitrous oxide and ventilation by pure oxygen (actually it was a mixture of air and oxygen), cyanosis promptly disappeared and the operation was completed uneventfully.

During the accident, the alarms, "low pac®" (Yamato Sanki) and "oxygen ratio monitor-controller®" (Dräger) which monitor the oxygen line pressure did not give the alarm. Therefore, we presumed that the decrease of oxygen concentration was not due to the decrease of bulk oxygen pressure but due to the mixture of nitrous oxide and air. After the operation all supply lines of oxygen and compressed air were checked. Several days later, we discovered an inappropriate connection of line betwen the compressed

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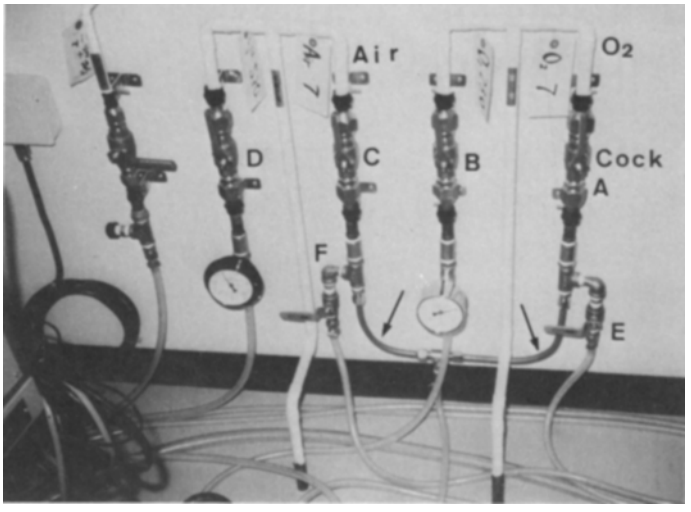

Fig. 1. The inappropriate connection (arrows) of the compressed air line (Air) and oxygen line (O_2). Cocks A and C are opened. (during reenactment)

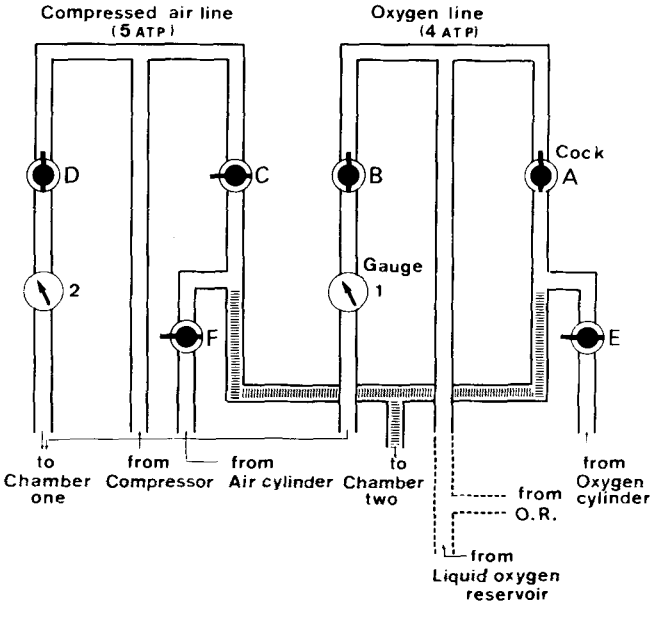

Fig. 2. Oridinary (correct) connection of line for the hyperbaric chamber. To send oxygen to chamber two which has only one inlet, cock A is opened and cock C is closed. To send oxygen or compressed air to chamber one which has two inlets, cocks B and D are opened.

air and oxygen of the hyperbaric oxygen chamber unit which was reconstructed seven months before (fig. 1). The line was connected as illustrated in figures 1, 2 and 3 (fig. 1, 2, and 3). Also, primary line pressure regulator had been adjusted to five atomosheric pressure (ATP) in commpressed air and four ATP in oxygen line. Furthermore, according to our operation records, compressed air to the hyperbaric oxygen chamber was applied for five minutes (from 3:05 to 3:10 p.m.). On the basis of these facts, we suspected the cause of the accident as follows: the inappropriate handling of the cock connected the compressed air line directly to the oxygen line and then the compressed air entered to oxygen line (fig. 3). Since there was approximately 100 meters of distance between the gas mixing site and operating theater, the oxygen contaminated with air reached to operating theater after a certain period of time. Based on these suspection, we reexamined that

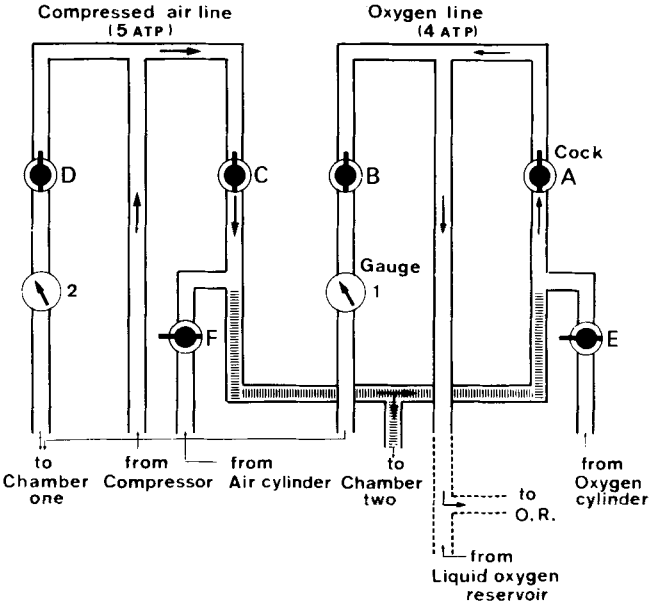

Fig. 3. During the accident, cocks A and C were opened, so compressed air passed through shaded line (inappropriate connection), as shown in fig. 1. Arrows indicate the path of compressed air to the operating theather.

the influence of the direct connection of compressed air and oxygen lines (fig. 1). Soon after compressed air line connected to oxygen line, pressure of oxygen line in the operating room increased from 3.75 ATP to 4.2 ATP. Fourteen and a half min later, the oxygen concentration of central supply line started to gradually decrease to 90%. After 16 min and 30 sec, the oxygen concentration measured with a oxygen monitor (Hama Ika) was 32% in the line and 16% in the anesthesia circuit, respectively. After 18 min, oxygen concentration in the line started to increase. Finally, 29 min after the cock was opened, the oxygen concentration returned to 98–100%. The result of the reenactment was almost a duplicate of those of the accident.

Discussion

Similar instances of intraoperative hypoxia have been reported: one was due to an erroneous filling of liquid oxygen[3], the other was caused by malfunction of oxygen blender[4].

Our accident was mysterious, because the operating theater has been built five years before and since that time, we had never experienced any accident such as the decrease of oxygen concentration in central supply system. The accident occurred at 100 min after the induction of anesthesia in one case and 160 min in three cases. We retrospectively reviewed the circumstances surrounding the accident and the result of our reenactment was almost identical to original situation, at the time of the accident. Since the line was connected correctly, such an accident has never occurred. It can be concluded that the decrement of oxygen concentration was caused by the inappropriate connection of the line between compressed air and oxygen and careless handling of the closing cock.

We could fortunately detect the lowered oxygen concentration by monitor in anesthesia circuit. The oxygen concentration was 16 and 17% in two patients. In another patient who were undergoing eye surgery in a dark room, recognition of hypoxia and cyanosis were delayed. In this patient, the oxygen concentration was 8%. According to our reenactment, minimal oxygen concentration in mixture of oxygen and compressed air was 32%. If we employ 32% of oxygen, instead of pure oxygen, for maintaining anesthesia (70% of N_2O, 30% of O_2), then the oxygen concentration would be 9.6% which is close to 8% level.

This means the oxygen concentration of the mixture would be slightly below 32% at the time of accident.

Needless to say, the prevention of fetal accidents during anesthesia largely depend upon the careful observation of the patients by anesthesiologist, but in dark operation room the observation are limited. Therefore mechanical aids, i.e., oxygen monitor and oxygen alarm on each anesthesia machine must be mandatory.

Moreover in our case, the gas mixture arrived to operating theater after 30 min through about 100-meter-supply line. This time interval depend on flow rate of mixed gas, pressure difference between compressed air and oxygen and the distance from the mixing site. An in-line-oxygen monitor in operating theater would have prevented hypoxia in two patients. Therefore an in-line-oxygen monitor is also important.

This connection of the pipe lines to hyperbaric oxygen chamber was initially designed technical convinience, but it should be emphasized that such mechanical errors should be discovered at the time of interventing, planning or construction. During the initial seven months after completion of the unit, we experienced twice a slight and transient reduction in oxygen line pressure, probably due to "blowing" (cleaning of the chamber). We recommend that the bulk oxygen supply apparatus to hyperbaric oxygen chamber unit should be separated from the line supplying the ward and operating theater.

An oxygen monitor in this case prevented a disastrous accident. The placement of an oxygen monitor and alarm system on the main oxygen line and each anesthesia machine is essential to defend against accident due to the decrements of oxygen concentration in central oxygen supply line and in the anesthesia.

(Received May 25, 1987, accepted for publication May 29, 1987)

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