Fuzzy logic control of inspired isoflurane and oxygen concentrations using minimal flow anaesthesia


Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
Fuzzy logic control of inspired isoflurane and oxygen concentrations in minimal flow general anaesthesia.

Type of intervention
Anaesthesia.

Economic study type
Cost-effectiveness analysis.

Study population
Patients undergoing discectomy for lumbar or cervical disc herniation for which general anaesthesia was a requirement.

Setting
Hospital. The economic study was carried out in Bern, Switzerland.

Dates to which data relate
The main effectiveness data were extracted from a clinical trial conducted in 1995. Resource and cost data were taken from 1995 sources. The price year was not clearly stated.

Source of effectiveness data
Effectiveness data were derived from a single study.

Link between effectiveness and cost data
The costing was undertaken prospectively on the same patient sample as that used in the effectiveness study.

Study sample
The study sample was a cohort of 30 patients undergoing discectomy for lumbar (26) or cervical (4) disc herniation. Power calculations to determine the sample size were not stated. Patients were allocated randomly to one of two groups: a standard group (15, 7 male; mean age 41) with low flow anaesthesia (1.2-1.3 litre/min.) and manual control versus a fuzzy logic group (15, 8 male; mean age 43) with minimal flow (0.5 litre/min.) and fuzzy logic feedback control of gas concentrations. Patients were shown to be similar in terms of sex, age, weight, duration of surgery (75 and 85 minutes in the two groups, respectively) and recovery time (17 and 16 minutes in the two groups, respectively) but were statistically different in relation to preoperative SAP (120 mm Hg and 130 mm Hg, respectively). Patients with coronary artery disease and diabetes mellitus were excluded.
Study design
This was a randomized controlled trial. The study period was divided into three phases: (1) induction phases - from the start of preoxygenation to the end of high flow anaesthesia; (2) maintenance phase - from the start of low-minimal flow anaesthesia to end of surgery; and (3) recovery phase - from the end of surgery to extubation. The loss to follow-up was not stated.

Analysis of effectiveness
The analysis of the clinical study would appear to have been based on intention to treat. The primary health outcomes used in the analysis were oxygen concentration, stability of anaesthesia as measured by SAP, the performance of fuzzy logic control of inspired isoflurane concentration and accumulation of foreign gases.

Effectiveness results
During the maintenance phase, the inspired oxygen concentration remained at 28-32 vol% for a longer period in the fuzzy than in the standard group. In one patient in the fuzzy logic control group and in five in the standard group, the inspired oxygen concentration reached a value of 26 vol%, at least once in each patient. The minimal value was 24 vol% which occurred once in both groups. The stability of anesthesia as measured by SAP 90-140 mm Hg in the two groups during the maintenance period was 97% and 96% in the standard group and in the fuzzy group, respectively. The stability of anesthesia as measured by SAP <90mm Hg in the two groups during the maintenance period was 0% in the standard group and 0% in the fuzzy group. The stability of anesthesia as measured by SAP >140 mm Hg in the two groups during the maintenance period was 1% and 2% in the standard group and in the fuzzy group, respectively.

The ability of the system to maintain isoflurane concentration, expressed by the frequency distribution of the deviation isoflurane concentration, measured 2 minutes after achieving the desired concentration, until the concentration was changed again, was analysed in 36 instances. The concentration was changed by 0.1% in 94% of the cases. Accumulation of foreign gases was observed in one patient during low flow and in 11 patients during minimal flow anesthesia. The inspired concentrations of oxygen, were 0.59 (standard) and 0.34 (fuzzy),(P<0.01), of nitrous oxide were 0.94 (standard) and 0.32 (fuzzy),(P<0.01), and of isoflurane were 18.2 (standard) and 16.2 (fuzzy).

Clinical conclusions
Fuzzy logic control achieved and maintained very accurately the desired isoflurane concentration. Oxygen concentration was controlled more precisely than in the standard group.

Measure of benefits used in the economic analysis
Cost savings were the measure of benefit.

Direct costs
Delivery and costs of gases (oxygen, nitrous oxide and isoflurane) were included in the analysis. Quantities were analysed separately from the costs. Discounting was not applied. The quantity/cost boundary adopted was that of the hospital. The price date was not clearly stated.

Currency
Swiss Francs (SF).

Sensitivity analysis
No sensitivity analysis was reported.

Estimated benefits used in the economic analysis
The estimated benefits were expressed as savings in costs.

Cost results
The delivery and costs of the oxygen was 0.64 SF/hour in the standard group and 0.37 SF/hour in the fuzzy group. The delivery and costs of isoflurane were 24.6 SF/hour in the standard group and 21.88 SF/hour in the fuzzy group. The delivery and costs of nitrous oxide was 1.96 SF/hour in the standard group and 0.67 SF/hour in the fuzzy group. Delivery and costs of oxygen and nitrous oxide were significantly lower in the fuzzy group (P<0.01)

Synthesis of costs and benefits
Costs and benefits were not combined.

Authors’ conclusions
Fuzzy logic control of inspired oxygen and isoflurane concentration during minimal flow anesthesia was reliable and reduced anesthetic gas delivery and costs.

CRD COMMENTARY - Selection of comparators
The reason for the choice of comparator is clear. Minimal flow anesthesia can be used instead of general and closed-circuit anesthesia methods both of which are subject to some limitations, for example, losses of gases through the escape valve as the flow of gases is increased (general anesthesia), or high leakage rates (closed-circuit anesthesia). You, as a user of this database, should consider whether these are widely used health technologies in your own setting.

Validity of estimate of measure of benefit
The estimate of measure of benefit used in the economic analysis is likely to be internally valid. The data have not been used selectively.

Validity of estimate of costs
Resources were reported separately from costs. Adequate details of methods of quantity/cost estimation were given. Important cost items were not omitted.

Other issues
The authors’ conclusions were justified. However, as stated by the authors, the experimental design was biased against the fuzzy logic system. Furthermore, as no sensitivity analysis was conducted, the results need to be treated with some caution. The issue of generalisability to other settings was not addressed, however, appropriate comparisons were made with other studies in terms of inspired isoflurane concentration and complications due to anaesthesia. The results were not presented selectively.

Implications of the study
Further research is required to analyse longer operations and a larger patient population.

Source of funding
None stated.

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Other publications of related interest

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