A comparison of bleeding when using hypotensive anesthesia versus normotensive anesthesia during LeFort I osteotomies

by

Robert Mark Dolman, D.D.S.

Faculty of Dentistry,
Division of Oral and Maxillofacial Surgery,
McGill University, Montreal

July, 1993

A thesis submitted to the

Faculty of Graduate Studies and Research

in partial fulfillment of the

requirements for the degree of Master of Science

in Oral and Maxillofacial Surgery.

Name Robert Mark Dolman

Dissertation Abstracts International is arranged by broad, general subject categories. Please select the one subject which most nearly describes the content of your dissertation. Enter the corresponding four digit code in the spaces provided.

Dentistry
SUBJECT TERM

0 5 6 7
SUBJECT CODE

U·M·I

Subject Categories

THE HUMANITIES AND SOCIAL SCIENCES

COMMUNICATIONS AND THE ARTS

Architecture 0729
Art History 0377
Cinema 0900
Dance 0378
Fine Arts 0357
Information Science 0723
Journalism 0391
Library Science 0399
Mass Communications 0708
Music 0413
Speech Communication 0459
Theater 0465

EDUCATION

General 0515
Administration 0514
Adult and Continuing 0516
Agricultural 0517
Art 0273
Bilingual and Multicultural 0282
Business 0688
Community College 0275
Curriculum and Instruction 0727
Early Childhood 0518
Elementary 0524
Finance 0277
Guidance and Counseling 0519
Health 0680
Higher 0745
History of 0520
Home Economics 0278
Industrial 0521
Language and Literature 0279
Mathematics 0280
Music 0522
Philosophy of 0998
Physical 0523
Psychology 0525
Reading 0535
Religious 0527
Sciences 0714
Secondary 0533
Social Sciences 0534
Sociology of 0340
Special 0529
Teacher Training 0530
Technology 0710
Tests and Measurements 0288
Vocational 0747

LANGUAGE, LITERATURE AND LINGUISTICS

Language
General 0679
Ancient 0289
Linguistics 0290
Modern 0291
Literature
General 0401
Classical 0294
Comparative 0295
Medieval 0297
Modern 0298
African 0316
American 0591
Asian 0305
Canadian (English) 0352
Canadian (French) 0355
English 0593
Germanic 0311
Latin American 0312
Middle Eastern 0315
Romance 0313
Slavic and East European 0314

PHILOSOPHY, RELIGION AND THEOLOGY

Philosophy 0422
Religion
General 0318
Biblical Studies 0321
Clergy 0319
History of 0320
Philosophy of 0322
Theology 0469

SOCIAL SCIENCES

American Studies 0323
Anthropology
Archaeology 0324
Cultural 0326
Physical 0327
Business Administration
General 0310
Accounting 0272
Banking 0770
Management 0454
Marketing 0338
Canadian Studies 0385
Economics
General 0501
Agricultural 0503
Commerce Business 0505
Finance 0508
History 0509
Labor 0510
Theory 0511
Folklore 0358
Geography 0366
Gerontology 0351
History
General 0578
Ancient 0579
Medieval 0581
Modern 0582
Black 0328
African 0331
Asia, Australia and Oceania 0332
Canadian 0334
European 0335
Latin American 0336
Middle Eastern 0333
United States 0337
History of Science 0585
Law 0398
Political Science
General 0615
International Law and Relations 0616
Public Administration 0617
Recreation 0814
Social Work 0452
Sociology
General 0626
Criminology and Penology 0627
Demography 0938
Ethnic and Racial Studies 0631
Individual and Family Studies 0628
Industrial and Labor Relations 0629
Public and Social Welfare 0630
Social Structure and Development 0700
Theory and Methods 0344
Transportation 0709
Urban and Regional Planning 0999
Women's Studies 0453

THE SCIENCES AND ENGINEERING

BIOLOGICAL SCIENCES

Agriculture
General 0473
Agronomy 0285
Animal Culture and Nutrition 0475
Animal Pathology 0476
Food Science and Technology 0359
Forestry and Wildlife 0478
Plant Culture 0479
Plant Pathology 0480
Plant Physiology 0817
Range Management 0777
Wood Technology 0746
Biology
General 0306
Anatomy 0287
Biostatistics 0308
Botany 0309
Cell 0379
Ecology 0329
Entomology 0353
Genetics 0369
Limnology 0793
Microbiology 0410
Molecular 0307
Neuroscience 0317
Oceanography 0416
Physiology 0433
Radiation 0821
Veterinary Science 0778
Zoology 0472
Biophysics
General 0786
Medical 0760

EARTH SCIENCES

Biogeochemistry 0425
Geochemistry 0996
Geodesy 0370
Geology 0372
Geophysics 0373
Hydrology 0388
Mineralogy 0411
Paleobotany 0345
Paleoecology 0426
Paleontology 0418
Paleozoology 0985
Palynology 0427
Physical Geography 0368
Physical Oceanography 0415

HEALTH AND ENVIRONMENTAL SCIENCES

Environmental Sciences 0768
Health Sciences
General 0566
Audiology 0300
Chemotherapy 0992
Dentistry 0567
Education 0350
Hospital Management 0769
Human Development 0758
Immunology 0982
Medicine and Surgery 0564
Mental Health 0347
Nursing 0569
Nutrition 0570
Obstetrics and Gynecology 0380
Occupational Health and Therapy 0354
Ophthalmology 0381
Pathology 0571
Pharmacology 0419
Pharmacy 0572
Physical Therapy 0382
Public Health 0573
Radiology 0574
Recreation 0575
Speech Pathology 0460
Toxicology 0383
Home Economics 0386

PHYSICAL SCIENCES

Pure Sciences

Chemistry
General 0485
Agricultural 0749
Analytical 0486
Biochemistry 0487
Inorganic 0488
Nuclear 0738
Organic 0490
Pharmaceutical 0491
Physical 0494
Polymer 0495
Radiation 0754
Mathematics 0405
Physics
General 0605
Acoustics 0986
Astronomy and Astrophysics 0606
Atmospheric Science 0608
Atomic 0748
Electronics and Electricity 0607
Elementary Particles and High Energy 0798
Fluid and Plasma 0759
Molecular 0609
Nuclear 0610
Optics 0752
Radiation 0756
Solid State 0611
Statistics 0463

Applied Sciences

Applied Mechanics 0346
Computer Science 0984
Engineering
General 0537
Aerospace 0538
Agricultural 0539
Automotive 0540
Biomedical 0541
Chemical 0542
Civil 0543
Electronics and Electrical 0544
Heat and Thermodynamics 0348
Hydraulic 0545
Industrial 0546
Marine 0547
Materials Science 0794
Mechanical 0548
Metallurgy 0743
Mining 0551
Nuclear 0552
Packaging 0549
Petroleum 0765
Sanitary and Municipal 0554
System Science 0790
Geotechnology 0428
Operations Research 0796
Plastics Technology 0795
Textile Technology 0994

PSYCHOLOGY

General 0621
Behavioral 0384
Clinical 0622
Developmental 0620
Experimental 0623
Industrial 0624
Personality 0625
Physiological 0989
Psychobiology 0349
Psychometrics 0632
Social 0451

Short Title: LeFort I surgery blood loss:hypotensive versus normotensive anesthesia.

TABLE OF CONTENTS

ABSTRACT

A prospective, randomized, blinded to the surgeon, clinical trial was used to compare the quality of the surgical field, blood loss and operative time when using either hypotensive or normotensive anesthesia during LeFort I osteotomies.

Twenty-three patients were randomized into one of the two groups.

Video imaging was used to assess operative time along with the quality of the surgical field. Intra-evaluator and inter-evaluator reliabilities were confirmed, intra-evaluator reliability being greater and scoring being more consistent.

There was a very highly statistically significant correlation ($p < .0001$) between surgeon's perception of the quality of the surgical field and blood pressure.

There was a statistically significant reduction ($p < .01$) in blood loss when using hypotensive anesthesia.

There was no statistically significant reduction ($p = 0.44$) in operative time when using hypotensive anesthesia.

RESUME

Cette étude prospective avait pour but de comparer les résultats d'une intervention chirurgicale (ostéotomies LeFort 1) auprès de deux groupes de patients. L'anesthésie hypotensive fut utilisée pour le premier groupe tandis qu'avec le deuxième groupe on utilisa l'anesthésie normotensive. Le chirurgien ne fut pas mis au courant de la pression sanguine de chacun des patients en question. Il s'agissait de vingt-trois patients ou le hasard détermina dans quel group chacun serait placé.

L'intervention chirurgicale fut enrégistrée sur vidéo cassette afin de déterminer la qualité du site chirurgical et d'évaluer la durée de l'intervention. Les précisions de l'intra-évaluateur ainsi que celles de l'inter-évaluateur furent confirmées. Les précisions de l'intra-évaluateur furent supérieures et la consistance de ses évaluations fut plus évidentes.

L'étude démontra qu'il existe dans la perception du chirurgien une correlation marquée ($p < .0001$) entre la qualité du site chirurgical et la pression sanguine.

Il y eut une réduction marquée ($p < .01$) dans la perte de sang lorsque l'anesthésie hypotensive fut utilisée.

La durée de l'intervention ne fut pas affectée par l'utilisation de l'anesthésie hypotensive ($p = 0.44$).

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to Dr. Kenneth C. Bentley who has directed this study and has given me constant help, guidance and support.

I am also grateful to Dr. Timothy W. Head and, again to Dr. Kenneth C. Bentley, for their patience and cooperation during the surgical procedures in this study.

Appreciation is extended to Dr. Mike English for the anesthetic management of the patients in this study and for his strict attention to all details.

Special thanks are in order to the Oral and Maxillofacial Surgery Residents, Dr. Pierre Monaghan and Dr. Normand Gervais, for the excellent care that they provided to the patients in this study, and for their precision in recording the data in this study.

Appreciation is extended to Dr. M. Abrahamowicz for his advice on evaluation of the data.

I would also like to express my appreciation to the nurses involved in the perioperative care of the patients in this study.

Appreciation is extended to Mr. John Labelle for his organization of the video imaging in this study.

My most sincere thanks to Miss Fiona Lees for the typing of this manuscript.

INTRODUCTION

The National Research Council of the United States of America has reported that approximately 5% of the population has an orthodontic problem of such significance that a combination of surgery and orthodontic therapy is required to correct the deformity.[1]

Hullihen in 1849[2] can be credited with the first operation to correct a malrelationship of the jaws. He performed a V-shaped ostectomy in the mandible to correct a malocclusion in a patient who had suffered severe scarring from facial burns.

Over the past century and a half orthognathic surgery has progressed to a level in which most dentofacial deformities can now be corrected utilizing a variety of surgical procedures performed via an intra-oral route.[3] These procedures usually include LeFort osteotomies, mandibular ramal and body procedures, subapical osteotomies and genioplasties.

The common factor amongst these procedures is that they are all performed within the limited confines of the oral cavity and surgical access can be problematic.[3,4] The head and neck area is a highly vascular region. A significant amount of bleeding may result from the cut edges of bone and soft tissue. Orthognathic surgical procedures involve manipulation of both hard and soft tissues.[5-9]

Considerable bone bleeding is often problematic because intra-bony hemorrhage is not easily controlled by conventional techniques. The compromise

of the operative site due to limited access compounds the issue of blood loss by prolonging the time to perform the osteotomies which in turn prolongs the hemorrhage from the bone and soft tissues [3 6 7]

McIndoe stated in 1955[10] "50 percent of a surgeon's time and a great deal of his nervous energy are devoted to controlling bleeding. The rest is concerned with the real object of the operation". He continued to report that most mistakes in surgery arise from not seeing rather than from not knowing.

Induced hypotension, deliberate hypotension, controlled hypotension, or hypotensive anesthesia are terms that describe an intentional reduction of systemic blood pressure below the level normally occurring during surgical anesthesia.[11] The technique was first employed in neurosurgical procedures[12], but over the past four decades hypotensive anesthesia has been used in orthopedic, gynecologic, urologic, thoraco-abdominal, plastic, otolaryngologic, ophthalmologic, and orthognathic surgical procedures.[5 90]

The rationale behind its use lies in the fact that it may reduce blood loss and the subsequent need for transfusion and its inherent risks. As a direct result of the reduction in blood loss and operative hemorrhage it is claimed to produce an improved, "dry" surgical field and, therefore, a decreased surgical time.[5 90] The reports in the literature are variable in their results and at times they are conflicting.

Does deliberate hypotensive anesthesia actually reduce operative blood loss and the resultant need for transfusion in orthognathic surgery? Is there an

improvement in the quality of the surgical field and a subsequent reduction in operative time?

These questions have been addressed by carrying out this study to assess the effectiveness of deliberate hypotension in reducing blood loss and operative time, and in improving the quality of the operative field. The study has been based upon the hypothesis that hypotensive anesthesia is better than normotensive anesthesia with respect to the foregoing. This was investigated via a prospective, randomized, blinded to the surgeon, clinical trial comparing normotensive versus hypotensive anesthesia during LeFort I osteotomies.

LITERATURE REVIEW

Hypotensive Anesthesia in General Surgical Procedures

The first attempt at deliberate hypotension was in 1946 when Gardner[12] employed arteriotomy under general anesthesia to reduce blood pressure deliberately during the excision of a vascular meningioma. Sixteen hundred milliliters (ml) of blood were removed from the dorsalis pedis artery, reducing blood pressure from 140 millimeters of Mercury (mmHg) to 100 mmHg. Although the tumor was extremely vascular, little blood was lost during the procedure. It was observed that bleeding was easily controlled with the electrocautery; clotting was rapid and clots were firm. It was noted that the tumor had been removed more satisfactorily and with less bleeding than in any other case in the surgeon's experience.

Harris and Hale in 1947[13] reviewed their experience using arteriotomy induced hypotension during 24 fenestration operations. They concluded "controlled induced hypotension has been found a very effective and safe procedure in the control of troublesome bleeding during the most difficult and important phases of the fenestration operation".

In 1948 Hale[14] reported his observation after having utilized arteriotomy induced hypotension for 24 craniotomies and 26 fenestration operations. He concluded that controlled induced hypotension was a valuable procedure for controlling hemorrhage in operations such as craniotomy and fenestration.

Griffiths and Gilles in 1948[15] utilized spinal block to reduce blood pressure during thoraco-lumbar splanchnicectomy and sympathectomy. Observations were made on a series of 84 operations involving 44 patients. They reported that the reduction in operating time and the complete insignificance of any blood loss are advantages which contribute to the undoubted value of the method and the satisfactory results achieved.

In 1950 Enderby[16] reported preliminary results using drugs and posture to reduce bleeding during surgery. He concluded that with an adequate reduction in blood pressure (systolic range of 60-80 mmHg) bleeding was "considerably" reduced.

Enderby and Pelmore in 1951[17] reported on their experience with hypotensive anesthesia during 250 operations. The type of procedures was not recorded. When the blood pressure was maintained at a level of 55-80 mmHg results were "entirely satisfactory". They concluded that there is a "considerable" reduction in bleeding and operations can therefore be done more quickly and more easily. As a direct result of these factors more extensive surgery was deemed possible at one operation where bleeding used to be the limiting factor. Their report was observational with no supporting objective data, statistical analysis or control group.

Hughes in 1951[18] reported on the use of hypotensive anesthesia in conjunction with postural changes during ten cases of fenestration operations. Systolic blood pressure was maintained at a level of 75-80 mmHg resulting in "excellent operating conditions".

Lewis in 1951[19] assessed the value of hypotensive drugs in minimizing blood loss during thoracic surgery. In 74 cases a systolic blood pressure of 60 mmHg or less was maintained and blood loss was negligible. In six cases systolic blood pressure could not be reduced below 90 mmHg and oozing was much greater. He concluded that a reduction in blood pressure minimized blood loss and decreased the need for extensive transfusion. This could have decreased operative time by providing a clearer field and reducing time taken for hemostasis.

In 1951 Shackleton[20] reported on his experience with controlled hypotension for reduction of surgical hemorrhage. He summarized that hypotension during surgery can produce "operating conditions of great attraction to the surgeon, can considerably reduce bleeding and therefore add to the patient's safety and post-operative health". He made reference to 250 cases in which three quarters of the cases were categorized by the surgeon as "good" with respect to reduction in bleeding. No study protocol with objective data nor statistical analysis was presented.

In 1951 Bilsand[21] reviewed 63 cases of craniotomy utilizing hypotensive anesthesia via arteriotomy. Systolic blood pressure was maintained at a level that would ensure a "sufficiently bloodless and accessible field for the surgeon", with a minimum value of 80 mmHg. He reported that there was a reduction of bleeding at the site of operation in all cases, although to a greater extent in some cases than in others. He concluded "the rapid, easy, bloodless exposures, the improvement in intracranial accessibility and reduction in surgical trauma, the

improved facility in manipulating and removing vascular tumors, aneurysms, etc., indicate that this method promises an important advance in the management of intracranial operations".

Rycroft and Romanes in 1952[22] reported their findings during ophthalmologic surgical procedures utilizing deliberate hypotensive anesthesia. They reviewed 100 of their own cases and 1000 cases handled by colleagues. They concluded "during extensive operations on the orbit which would normally result in considerable hemorrhage, it is uncanny to see no bleeding from the incision; no sucker is necessary and no artery forceps are used when postural hypotension has been established. The detailed dissection of structures is easy and the definition of fine detail in the orbit can be carried out with ease".

Boyan and Brunschwig in 1952[23] reviewed 32 cases of extensive operations for advanced pelvic and abdominal cancer. Blood pressure was deliberately reduced to a systolic range of 45-65 mmHg. They reported that it was the very distinct impression that these operations were appreciably facilitated and the blood loss reduced as a result of the hypotensive anesthesia.

Korkis in 1953[24] reported on 49 cases using hypotensive anesthesia. Surgical procedures included fenestrations, mastoidectomies, facial nerve explorations, ethmoidectomies, Caldwell Luc procedures, thyroidectomies, laryngectomy, branchial cyst and salivary gland excision. From the surgeon's viewpoint, the results in the aural cases were excellent in most of the cases, but not all. In major neck surgery it aided in reducing operative time and decreasing

blood loss. Surgery was improved when the operation included work in "small, dark, deep cavities".

Stammers in 1953[25] reported on his experience with hypotension during anesthesia for 1000 major surgical procedures and concluded that it diminished the blood loss considerably.

Langston in 1953[26] reported on a group of surgical procedures performed with deliberate hypotensive anesthesia at a systolic blood pressure range of 55-65 mmHg with a moderate foot down tilt. Surgical procedures included pneumonectomies, lobectomies, decortication of a lung, thoracoplasties, lumbodorsal sympathectomies, craniotomies, and plastic surgery. In the pneumonectomy group, average blood loss per case was 530 ml when hypotension was used versus 1850 ml in a control group. In the thoracoplasty group the average blood loss was 420 ml in the hypotensive group and 1175 ml in the control group. In the lobectomy series blood loss ranged from 150-1350 ml in the hypotensive group and 675-3100 ml in the control group. Langston concluded that these results "proved beyond doubt that it is possible to markedly reduce surgical hemorrhage" with controlled hypotension.

Cox in 1953[27] reported on his experience with hypotensive anesthesia. He stated that a bloodless field, resulting in improved vision and exposure, led to an easier operation and reduction in surgical time. He measured blood loss in a series of cases by placing the collected blood and blood soaked material in a known quantity of water and ammonia. The hemoglobin concentration of this mixture

was compared to the patient's hemoglobin giving an estimate of blood loss. He gave examples of thyroidectomy blood loss. Without hypotension the blood loss was 260 ml versus cases with hypotension in which blood loss was 30 ml. Similarly, radical mastectomy without hypotension resulted in blood loss of 690 ml versus 32 ml for cases with hypotension. Prostactomy performed without hypotension resulted in blood loss of 550 ml versus 30 ml when performed with hypotension. Thoracotomy with hypotension had blood loss of 160 ml versus nonhypotensive surgery with a blood loss of 1160 ml. Pelvic evisceration was accompanied with a blood loss of 1500 ml without hypotensive anesthesia versus 160 cc when hypotensive anesthesia was employed. He continued in comparing the frequency of transfusions during and 24 hours after prostatectomy performed with and without hypotensive anesthesia. The incidence was one out of two cases and one out of six cases respectively. Although his results were favourable, his report was retrospective and anecdotal with no study design and no statistical analysis.

James *et al* in 1953[28] reported on 300 neurosurgical cases. One hundred and fifty cases were performed under hypotensive anesthesia and the second 150 cases were done without hypotensive anesthesia. The majority of cases were laminectomies and craniotomies for various types of pathoses. In the hypotensive group an attempt was made to maintain systolic blood pressure below 65 mmHg. There were no parameters indicated for the blood pressure in the normotensive group. Patient position varied from either prone or "jackknife" or lateral, or lateral

with shoulder raise, or prone with chest and abdomen raised off the table. Minimal or slight bleeding was designated "satisfactory" and normal or excessive bleeding was considered "unsatisfactory". Laminectomy and craniotomy groups were compared separately. They concluded that induced hypotensive anesthesia reduced mortality and transfusion and led to a slightly shorter duration of anesthesia. Furthermore, the reduction in bleeding allowed for a higher standard of surgery. No transfusion criteria were given. The number of surgeons involved was not indicated, and no objective statistical data were reported. There was variability in patient position which may have affected bleeding unequally in the two groups.

In 1953 Anderson and McKissock[29] reported on the use of hypotensive anesthesia to a systolic blood pressure of 60-70 mmHg during 52 craniotomies in which only two cases had a level of blood loss that required transfusion. No transfusion criteria were indicated. They concluded that very few of the cases would have been possible without some form of induced hypotension. Furthermore, they added that the reduction in blood pressure led to a reduction in operative time, anesthetic requirements, and blood loss and reduced the risk of certain intracranial complications. This was a review of cases with no objective statistical data.

In 1953 Nicholson *et al*[30] reviewed their experience with 25 cases utilizing induced hypotension. The majority of the cases were neurosurgical. They reported that it was the impression of the operating surgeons that the tendency to bleed and actual blood loss was less than would have been anticipated had the blood pressure remained normal. This was an observational report.

Stevens and Tovell in 1954[31] reviewed their experience using deliberate hypotension on 91 patients undergoing major orthopedic surgical procedures. The procedures included hip, femur, shoulder, and spine operations. They outlined the need for transfusion in their series of patients yet no comment was made on whether there was a reduction in blood loss from cases treated with normotensive anesthesia. They did, however, conclude that they had been impressed with the usefulness of hypotensive anesthesia.

In 1954 Kilduff[32] reviewed his experience with controlled hypotension and reported "induced hypotension simplified extensive and radical surgery on the head and neck. Operations can be undertaken where a bloodless field is vital for success. With the use of hypotensive drugs blood loss at operation is either negligible or greatly reduced. The need for blood transfusion with its attendant hazards is abolished, and the possibility of excessive transfusion is avoided".

At the same time in 1954 Scurr and Wyman[33] presented a more equivocal report. They reviewed 250 cases of various surgical procedures utilizing hypotensive anesthesia of varying degrees. They reported that by combining appropriate posture with controlled hypotension, "satisfactory" control of hemorrhage could be attained in a very high proportion of cases. They did emphasize, however, that the ischemia of the operative field was not always commensurate with the hypotension. Some patients with a systolic pressure of 80 mmHg presented a completely dry field whereas in other cases there was oozing despite a systolic blood pressure level of 40 mmHg.

In 1954 Mandow *et al*[34] reviewed 442 surgical cases performed using induced hypotension. There were no actual blood loss measurements, yet their impression was that bleeding was satisfactorily controlled in 428 cases. They concluded that blood loss was reduced to the extent that replacement by transfusion was hardly ever needed, operative time was reduced, and certain technically difficult procedures were made easier with controlled hypotension.

In 1955 Stirling[35] utilized hypotensive anesthesia during 20 fenestration procedures. He reported "the technique produces the bloodless field which is not merely a help in the technical performance of the operation, but is essential to its ultimate success".

In 1955 Safar[36] presented a prospective report in which he compared 20 radical mastectomies performed with hypotensive anesthesia and 20 radical mastectomies performed without hypotensive anesthesia. The surgeon and anesthetist were the same for all cases. He observed that it was easier to clamp bleeding points in the hypotensive group. Furthermore, less clamps were used, average surgical time was 26 minutes shorter, average reduction in blood loss was 462 cc. There were, however, transfusions in all but one hypotensive case. Additionally he reviewed ten thoracic procedures with ten controls. The controls did not compare closely with the treated group. It was observed that reduction in blood loss was "considerable", dissection was facilitated by the hypotension, and there was a decrease in oozing. Safar concluded that standard operations which could safely be performed under normal anesthetic conditions without excessive

hemorrhage were no indication for the selection of deliberate hypotension. He continued by stating that although the measured blood loss was reduced it was not to a degree that eliminated transfusion. It was his impression that the main advantage of improved surgical field quality was not justification in itself for use of deliberate hypotension. Rather, the technique should be used in those cases which would normally be inoperable or in those cases where large transfusions would lead to uncontrollable oozing.

In 1956 Mazzia *et al*[37] reviewed 295 craniotomies performed for variable pathoses under hypotensive anesthesia. These were compared to 201 craniotomies done without hypotensive anesthesia. Most of the procedures were performed by the same surgeon. A varying number of cases utilized reverse Trendelenberg of 15-25 degrees. They compared similar procedures. Operative time was found not to be significantly different. Furthermore, blood replacement in the series with hypotensive anesthesia was in general 500 cc less than the control. However, an equal percentage of patients in both series required 2000 cc or more of whole blood, demonstrating that induced hypotension was no guarantee against an occasional instance of major blood loss.

In 1956 Royster and Ditzler[38] reviewed 34 patients who underwent radical head and neck operations utilizing controlled hypotension to a systolic blood pressure range of 40-90 mmHg. This group was compared to 26 patients with similar types of operations performed with no hypotensive anesthesia. No blood pressure parameters were outlined in this group. All patients had a diagnosis of

"some form of cancer". Pre-operative radiotherapy status was not reported. For comparison, patients were divided into three groups, "simple" radical neck dissection, radical neck dissection and insertion of radium needles, and extensive and varied head and neck operations. This last group was subdivided according to the extent of surgery. The procedures varied from jaw-tongue-neck dissection, to ear-neck-parotid dissection, to maxillary resection, to upper neck-mandible dissection. Blood loss was measured by volumetric and gravimetric techniques. The authors concluded that hypotensive anesthesia provided a "definite retardation" in bleeding at operation and that dissection was greatly facilitated by the nearly "dry" field. There was no reduction in operative time. This was a retrospective case review. Trends were identified, but because surgical procedures were not exactly the same, useful statistical data could not be obtained.

Holmes in 1956[39] reported on a four-year review of 407 orthopaedic operations with the use of hypotensive anesthesia. In most cases the systolic pressure fell to between 50-65 mmHg, "while diastolic pressure was often difficult to assess accurately". Surgical procedures were performed on the hip, femur, shoulder, humerus and spine. Three hundred and seventy cases required no blood replacement. The remaining 37 cases required blood transfusions between 500-5000 ml. This need for transfusion was explained on the basis of either (i) low pre-operative hemoglobin, (ii) increased blood loss due to inadequate reduction in blood pressure or inadequate elevation of the surgical site, (iii) prophylactic in extensive operations, or (iv) reactionary hemorrhage. No criteria for transfusion

were outlined. He also compared 262 cases with induced hypotension to 336 similar procedures by a different surgeon. He found the range of blood transfusion to be 27-180 ml in the hypotensive group versus 743-2650 ml in the normotensive group. It was concluded that induced hypotension can effect a considerable saving of blood. Surgeons generally agreed that operating conditions were improved and the duration of operation shortened. There was no prospective study outline established. The author reported on his experience with hypotensive anesthesia and used another surgeon's data as control.

Ditzler and Eckenhoff in 1956[40] retrospectively reviewed 90 surgical procedures with various methods of anesthesia and a variety of hypotensive techniques producing a systolic blood pressure of 60-80 mmHg. Included in this group were 29 patients who underwent radical neck dissections. These patients were compared to 20 patients undergoing similar surgical procedures with "standard anesthetic techniques". No mention was made of the average pressure in the control group. Also included in their review were 28 patients undergoing radical dissection within the pelvis. Seventeen of the patients were subjected to deliberate hypotensive techniques whereas 11 were treated with "standard" anesthetic methods. They found that hypotensive techniques reduced the amount of blood loss as measured by volumetric and gravimetric techniques. However, there were no statistical analyses used. The reduction in blood loss was 35% which represented 1 unit per patient of blood saved in radical neck dissection and 2 units per patient in radical pelvic dissection. However, it was still necessary to

transfuse 2 units per patient in the radical neck dissection group and 4 units per patient in the radical pelvic dissection group. No transfusion criteria were outlined. Therefore, although blood loss was reduced, the risk of transfusion was not eliminated. They also commented that deliberate hypotension did not guarantee a reduction in blood loss. "Some surgeons have commented that occasionally patients demonstrate more oozing at the lower blood pressure than at a higher pressure". Operative time was not reduced by deliberate hypotension. In fact, on the average it was higher. This was explained in two opposing ways: (i) blood loss did not hamper dissection, or (ii) the drier field permitted more extensive, complete dissection, better teaching, and reduced pressure on the surgeon to operate rapidly.

In 1957 Cox[41] reported on his experience with induced hypotension during prostatectomy. He stated "when the rate of bleeding is reduced, it is very much easier to see the points that are bleeding and therefore their control is more easily and rapidly accomplished". He continued by saying "for myself, the use of hypotensive anesthesia and an irrigating catheter have much reduced the anxieties which I have about my patients bleeding after prostatectomy".

In a critique of Cox's report, Jacobs in his communication to the British Journal of Urology in 1957[42] stated that he frequently performed retropubic prostatectomy "without using a single gauze swab after the abdominal wall incision has been made". He argued that in this procedure bleeding of a degree sufficient to warrant hypotensive anesthesia should rarely be required.

Conversely, Walters[43] in the same journal reported "I have been surprised that so few of my surgical friends use hypotension for prostatectomy. I can assure them that it makes all forms of prostatectomy more simple owing to the accuracy with which the operative procedure can be carried out and hemostasis effected".

Shepperd[44] supported Cox in his letter to the British Journal of Urology. He reported improved hemostasis and blood loss reduction in using hypotensive anesthesia during approximately 1000 retropubic prostatectomies and endoscopic resections.

Scott in 1958[45] reviewed his experience with deliberate hypotension via high spinal analgesia. Comments were based on 107 radical hysterectomies performed with this technique at a usual systolic blood pressure of 60-65 mmHg. The author concluded "the most striking feature is the bloodlessness of the operative field". Visualization was also improved. This was an anecdotal report of the author's experience. No study data were presented.

In 1958 Tomskey *et al*[46] reviewed six cases of unilateral nephrolithotomy utilizing controlled hypotension at a systolic blood pressure range of 60-80 mmHg They argued that patients requiring nephrolithotomy and who have had previous operations often have significant fibrosis and scarring which leads to difficult surgical exposure and hemorrhage control Their case review led them to conclude that the bloodless field provided by this procedure facilitated the operation and minimized blood loss. The use of the technique was justified because it facilitated the surgery, reduced blood loss and decreased transfusions. No transfusion criteria

were reported. It is important to note that although the blood replacement was "considerably less than is ordinarily required when tourniquets and clamps are used", each patient did require a minimum of 1 unit of blood replacement. This was a case review report with no prospective outline or control group

In 1959 Bodman[47] reviewed 100 cases of prostatectomy. Surgery was performed in 48 patients with deliberate hypotensive anesthesia to a systolic blood pressure below 100 mmHg. The systolic pressure "usually" fell to between 60-75 mmHg. A control group consisted of another 52 patients, two of which were failed hypotensive patients in which systolic blood pressure could not be reduced below 100 mmHg. The anesthetic agents and techniques used were the same in both groups. A head down tilt of 10 degrees was used in all cases. The same anesthetist was involved in all cases. The number of surgeons involved was not documented. The type of pathosis was not identified. Variation in disease may contribute to a difference in hemorrhage. Blood loss was measured by the amount aspirated into the suction bottle. The use of swabs was discouraged and care was taken not to aspirate water within the wound. The average blood loss in the control group was 346 ml compared to 94 ml in the hypotensive group. This was considered highly significant ($p < 0.0001$). Transfusions were given when blood in the suction bottle was 280 ml or more. Thirty patients in the control group required transfusion. No patients in the hypotensive group required transfusion. The author concluded that a reduction in blood pressure reduced the blood lost during prostatectomy and therefore assisted the surgeon by improving the quality

of the surgical field. There was no measure of quality of the operative field employed in this report. The ability to suction blood selectively and not irrigation fluid along with the omission of blood in the sponges, although constant from patient to patient, is likely filled with error.

Gusterson in 1959[48] described his experience with halothane for prostatectomy. He stated that the fall in blood pressure achieved when using halothane enabled blood loss at operation to be controlled. Thirty-five patients undergoing Millin's retropubic operation were evaluated. Fifteen patients had hypotensive anesthesia in which systolic blood pressure averaged 90-100 mmHg with a lower limit of 80 mmHg. There were ten patients in a nonhypotensive group but no blood pressure parameters were identified. There was no standard random selection system used. All patients were in a 10 degree Trendelenberg position. All patients were given a slow blood drip during surgery. There was more than one surgeon and more than one anesthetist involved in the treatment of these patients. The authors documented a reduction in blood loss with hypotensive anesthesia although no statistical analysis was presented. Reference was also made to improved operating conditions. Blood loss was measured by comparing hemoglobin content in sponges and bottles to the patient's pre-operative hemoglobin level. This study lacked randomization and surgeons were not blinded to anesthetic technique. Improved operative conditions were merely observational, not measured.

Murtagh in 1960[49] described his experience with induced hypotension employed on 55 patients. Thirty of these patients underwent various thoracic surgical procedures at an average systolic blood pressure of 71 mmHg. Twenty five patients underwent radical mastoid surgery or tympanoplasty at an average systolic blood pressure of 63 mmHg. It was observed that bleeding from cut surfaces was markedly reduced and as a consequence the dissections in both groups were technically much easier to perform. There was no statistical data analysis of blood loss or quality of surgical field in this retrospective case review.

In 1960 Moersh *et al*[50] reviewed 326 cases of mastectomy. One hundred and ninety-seven cases were performed with deliberate hypotensive anesthesia. Systolic blood pressure averaged 80 mmHg. These cases were compared to the remaining 129 cases in which no hypotension was employed. Forty-eight patients had simple mastectomy with axillary node dissection. Two hundred and seventy eight patients had radical mastectomy. The results revealed no significant reduction in blood loss as measured by hemoglobin concentration. They did find, however, a reduction in the need for transfusion from 31% in the normotensive group versus 7% in the hypotensive group. No transfusion criteria were outlined. The authors concluded "induced hypotension reduces loss of blood to such a degree that transfusions are seldom necessary, which in itself is a cogent argument for the use of hypotensive anesthesia". They continued to state that increased visibility, resultant ease of surgical procedures, reduction in blood loss and need for transfusion constituted the major advantages of the technique. This was a

retrospective study with no statistical analysis. Surgical techniques varied which altered blood loss measurements. The systolic blood pressure range in the hypotensive group from 54-105 mmHg placed some patients into a normotensive category. There was no absolute measure of actual blood loss.

In 1960 Bruce *et al*[51] reported their experience on retropubic prostatectomy. Ninety-two patients were involved in the study. The use of hypotensive versus normotensive anesthesia was determined by the desires of the surgeons. Many surgeons and anesthetists were involved. The anesthetic technique was standardized. The hypotensive group (31 patients) had systolic blood pressure maintained at about 60 mmHg. No parameters were listed for normotension (61 patients). Head down tilt was set at 10-15 degrees. The patients in the normotensive group lost about three times as much blood as those in the hypotensive group. There were no transfusions in the hypotensive group. Thirty-three percent of the normotensive patients required transfusion. The indication for transfusion was a loss of three quarters of a pint or more depending on the rate of loss and the patient's clinical condition. In order to eliminate surgeon variability, 16 cases of a single surgeon were reviewed. Ten patients underwent surgery with hypotensive anesthesia and six patients were operated on with normotensive anesthesia. The overall blood loss differences did not vary from the initial group of patients reviewed. The authors concluded that controlled hypotension "considerably" reduced blood loss during retropubic prostatectomy. Furthermore, surgical conditions were improved and hemostasis was facilitated. Transfusion was "virtually" eliminated.

Riches in his letter to the British Journal of Urology in 1960[52] supported Bruce's conclusions. He stated "it is better that a low blood pressure should be produced and controlled by the anesthetist than that it should be due to excessive loss of blood which must be replaced by transfusion".

Jacobs in 1960[53] maintained that blood loss during retropubic prostatectomy is "not generally a serious problem". He did, however, acknowledge Bruce's results and stated that hypotensive anesthesia would seem "worthy of an extensive trial".

Holloway *et al* in 1961[54] reviewed 19 cases of microsurgery of the middle ear. The "wound ischemia" was rated as good: virtually bloodless, fair: sufficiently bloodless to make uninterrupted microsurgery possible, and poor: bleeding sufficient to impede microsurgery, even if only periodically. Two cases were resistant to hypotensive techniques. Systolic blood pressure was maintained at 90-95 mmHg. The surgical field was "poor". Seventeen cases were initially resistant to hypotensive techniques. The operative site was rated "poor". When blood pressure was reduced, 16 sites became "good" and one became "fair".

In 1961 Linacre[55] reviewed 1000 gynaecological surgery cases performed with deliberate hypotension. The surgical field was categorized as "dry" when the operative site was not obscured by a continuous ooze and pooling did not occur, "fair" when an initially dry field deteriorated and when further measures were necessary to improve operating conditions, or "wet" when the field was apparently unaffected and suction often necessary. Results indicated 88% dry, 10.5% fair and 1.5% wet.

In 1962 Hayward-Butt and Kos[56] reported their experience using induced hypotensive anesthesia during endaural surgery. Fifteen patients were selected at random and compared to a retrospective control group who had similar surgical procedures performed under local analgesia without hypotension. Patient position was standardized. Hypotension was induced in these 15 patients when the operative field called for a "dry bed". Hypotensive anesthesia was augmented with 2% lidocaine with epinephrine in a concentration of 1 in 200,000. The criterion of success of the method was the state of bloodlessness of the surgical site. The following scale was used: grade 0, completely dry field, grade 1, slight oozing requiring mopping or suction every three minutes or so, grade 2, some oozing requiring attention each minute or so, grade 3, oozing sufficient to hinder surgical manoeuvers. After outlining this elaborate scheme, the authors did not use it in their report of results. Rather, they stated that 12 of the 15 patients had "dry fields" requiring virtually no suction. Three patients had oozing similar to what existed in local anesthesia cases. The systolic blood pressure was not prospectively set at a specific level but rather retrospectively observed to be between 60-90 mmHg, a value required to produce optimal conditions in each case. The surgeons were not blinded to anesthetic technique and there was no indication if the scale was standardized between observers or within each observer.

In 1963, Chamberlin[57] reviewed his experience with hypotensive anesthesia and reported on a comparison of two groups of patients undergoing a wide variety

of ablative head and neck surgical procedures. Thirty-seven patients had induced hypotension to a level required to "dry" the surgical field without producing any electroencephalographic changes. This resulted in a systolic blood pressure range of 35-65 mmHg. Thirty-two patients had undergone similar surgical procedures two years before with normotensive anesthesia. Operative time was reduced by 65% and blood loss was decreased by 46%.

In 1964 Baker[58] reported on 665 cases of prostatectomy with varied pathoses performed under controlled hypotension. He observed that bleeding was minimal and post-operative transfusions were needed in only eight cases. He stated, "we are greatly indebted to our anesthetists for their method of producing hypotension and for giving us an operative field which really allows us to see what we are doing".

Boreham in 1964[59] reported on his experience with 150 cases of retropubic prostatectomy performed with hypotensive anesthesia. During these procedures the aim was to achieve a systolic blood pressure of 70 mmHg. He observed blood loss measurements ranging from one to ten ounces with a usual range of one to three ounces. He reported that the blood loss seemed to vary irrespective of the blood pressure during or before the operation. Some patients with an operative systolic blood pressure of 90 mmHg bled very little, whereas some patients with a systolic pressure of 50 mmHg bled more than was "convenient". Seven of 150 patients required transfusions. This was compared to a transfusion rate of 50% on cases that were performed before hypotension was in use. Boreham concluded

that deliberate hypotension was a technique that "enormously" reduced the amount of bleeding during the operation which made it easier, safer and more accurate. This report was observational. No statistical data were presented.

In 1964 Slade *et al*[60] reviewed blood loss in prostatic surgery. Patients underwent retropubic or transurethral prostatectomy. Anesthesia was either general with hypotension, general without hypotension, or regional (caudal, epidural, spinal). The systolic blood pressure for the hypotensive group was approximately 60 mmHg versus 75-85 mmHg for the epidural group and 80-100 mmHg for the spinal group. No range was reported for the normotensive anesthesia group. Blood loss was lowest in the hypotensive group and highest in the normotensive group, with the regional block group in an intermediate range between the two. No statistical analysis was used to identify the significance in the reduction of blood loss. The need for transfusion was quite variable. In the transurethral prostatectomy group 17% of normotensive patients required transfusion versus 14% for hypotensive patients. The patients who had a spinal block had a transfusion incidence of 30% versus 10% for the epidural group. The authors explain the variability on the basis of anesthetist preference for transfusion. In the group undergoing retropubic prostatectomy 47% of the normotensive patients required transfusion versus 14% in the hypotensive group. The regional block group was in an intermediate position. It is difficult to weigh the significance of these results without statistical analysis. The indications for transfusion were blood loss exceeding 400 cc. There was no outline of specific

protocol in this report. Although the authors concluded that a moderate hypotensive technique was valuable in reducing blood loss and improving the quality of the surgical field, their results were merely trends, as statistical analysis was not performed.

In 1966 Eckenhoff and Rich[61] reported on 231 cases, 115 completed with hypotensive anesthesia. Four surgical procedures were performed and these were compared to similar surgical procedures with no hypotensive anesthesia. The procedures included rhinoplasty, portocaval shunt, craniotomy for aneurysm, and craniotomy for suspected tumor. There was an "appreciable saving in blood loss" with a decrease in operative time, although not an "impressive" reduction. The authors reported "a relatively bloodless operative field at the proper time is spectacular". Forty four patients underwent rhinoplasty with controlled hypotension with a systolic blood pressure ranging from 50-80 mmHg. The normotensive parameters were not reported. Furthermore, only the hypotensive group had head elevation at 20 degrees. There was a 25% reduction in blood loss and operative time in the hypotensive group versus the normotensive group. Fourteen patients had portocaval shunt insertion with hypotensive anesthesia. This group was compared to 25 previous patients who had undergone similar surgical procedures under normotensive anesthesia. Three of the 14 patients in the hypotensive group required an emergency operation because of uncontrollable bleeding. Twelve of 25 patients in the normotensive group also required an emergency operation. Systolic blood pressure in the hypotensive group ranged

from 48-80 mmHg. There were no parameters reported for normotensive pressures. It is important to recognize that the uncontrollable bleeding in the normotensive group may have rendered these patients hypotensive albeit not controlled, induced, or deliberate. There was a 42% reduction in the amount of blood replacement in the induced hypotensive group, yet all patients required transfusion. There were no transfusion criteria reported. Operative time was not altered by hypotensive anesthesia, yet 12 surgeons were involved in these operations. Thirty-six patients had craniotomy for suspected tumor utilizing hypotensive anesthesia with a systolic blood pressure range of 40-104 mmHg. The data were compared with 37 patients whose procedures were performed without hypotensive anesthesia. The average amount of blood required for replacement was 60% less in the hypotensive group than the control group. No transfusion criteria were reported. There was a slight decrease in operative time yet more than one surgeon was involved in the procedures.

In 1965 Smith *et al*[62] reviewed 182 patients who had undergone standard radical mastectomy that included removal of breast and pectoral musculature along with axillary dissection. This group was compared to 32 patients who had the same operation with no hypotension. All of the operations were performed by the same surgeon. Hypotension was set at a systolic blood pressure necessary to produce a dry surgical field with a range of 65-110 mmHg. No parameters were reported for the normotensive group. The average surgical time was 93 minutes for the hypotensive group and 90 minutes for the nonhypotensive group There

were transfusions in nine of 32 normotensive patients and 12 of 182 patients treated with hypotension. No transfusion criteria were reported. Together with a previous report, they reviewed a total of 379 cases over a ten-year period and concluded that the major advantage of this technique was the facilitation of the operation, although apparently there was concomitant conservation of blood. The duration of surgery was unaffected. This was also a retrospective review with no statistical analysis.

Sleath and Archer in 1967[63] restrospectively reviewed the charts of 140 patients who underwent laminectomy or spinal fusion or a combined procedure of laminectomy and spinal fusion. All patients were positioned prone with cylindrical bolster support. Patients were divided into two groups according to their operative blood pressure drop from pre-operative baseline. Those patients who had a reduction in systolic blood pressure greater than 30 mmHg were categorized as hypotensive. Those patients whose reduction in blood pressure was 0 to 29 mmHg were categorized as non-hypotensive. The authors found that the 71 patients whose blood pressure was reduced 30 mmHg or greater had significantly less bleeding than those in the second group.

In 1969 Donald[64] reported on 122 females that underwent amputation of the cervix, anterior colporrhaphy and posterior colpoperineorrhaphy with various methods of anesthesia with and without controlled hypotension. The surgery was performed by a group of gynaecologists amongst whom a common policy of radical repair was practised. All patients were placed in the lithotomy position with a 5

degree head down tilt. Hypotension was defined as a stable systolic blood pressure ranging from 60-80 mmHg as measured by an upper arm cuff. Patients were categorized into groups by chart review. When hypotension was induced with each basic anesthetic technique, blood loss as measured by gravimetric techniques was significantly reduced by approximately 50% ($p < 0.001$).

In 1970 Taylor *et al*[65] described their experience using sodium nitroprusside as a hypotensive agent during head and neck and neurosurgical procedures. They reported that the operative field was "dry" and acceptable to the surgeons using the operating scope.

In 1971 Deacock[66] commented on 5000 middle ear operations over a ten-year span along with 600 personal cases. He reported "controlled hypotension greatly reduces bleeding, and is the only consistently reliable way of doing so". He made reference to 53 of his cases in which bleeding was "excessive" and subsequent induced hypotension produced a "dramatic improvement".

At the 40th Annual Meeting of the American Academy of Orthopedic Surgeons in 1973 Jennings *et al*[67] reported on a series of 50 patients who had total hip replacements with controlled hypotension to a level of 65-75 mmHg. It was not noted whether this was the average systolic pressure or the average mean arterial pressure. Twenty-five of these patients had had previous surgery. The average blood loss required 890 ml of packed cells and 840 ml of albumin as replacement for the patients who had had previous surgery, and 570 ml of packed cells along with 580 ml of albumin for the patients who had no previous

operations. The control group had an average total blood replacement of 2965 ml for those who had had previous surgery and 2250 ml for those with no previous surgery. There was no information regarding patient position, number of surgeons involved, hip pathosis, normotensive blood pressure, criteria for transfusion, randomization, or prospectivity.

In 1973 Mallory[68] reported his "favorable" experience with deliberate hypotension. Forty patients undergoing total hip replacement had controlled hypotension. These patients were compared to a similar surgical group treated with normotensive anesthesia. Operative time was reduced by 25% because of improved hemostasis. When categorizing patients into groups having had previous surgery versus first time surgery and comparing them to similar controls, there was a reduction in blood loss in the hypotensive group by 40-55%. There was a 50% reduction in post-operative blood transfusions. No transfusion criteria were presented. Mallory concluded that controlled hypotensive anesthesia in patients undergoing total hip replacement appeared to be an effective means of reducing morbidity in this major surgical procedure with no change in risk to patients. This was a letter to the editor summarizing the author's experience. There was no study protocol outlined.

Davis *et al*[69] in 1974 prospectively reviewed 253 cases of total hip replacement, the first 50 being performed by the same surgeon and anesthetist under hypotensive anesthesia. Systolic blood pressure was maintained between 60-75 mmHg. These cases were compared to 62 similar preceding cases also

performed by the same team without hypotensive anesthesia. The systolic blood pressure range was not reported. A variable number of patients had had previous hip surgery and not all patients required trochanter osteotomy. Blood loss was measured by volumetric and gravimetric methods. There was an overall reduction in blood replacement of 40-50% when hypotensive anesthetic was employed, although all patients received an average of two to three units of blood Blood volume was carefully maintained by matching the measured loss with packed red cells as well as albumin in saline. Patients who had had previous surgery were compared separately. The value of these results is questionable. Some patients had osteotomies and some did not. This can contribute to differences in blood loss. Surgeons were not blinded to the anesthetic technique and no objective scheme was used to assess the quality of the surgical field.

In 1974 McNeill[70] reported on a retrospective study comparing 22 patients using normotensive anesthesia and 44 patients utilizing controlled hypotension during spine fusion. The use of hypotensive anesthesia was found to reduce the need for blood replacement and total blood loss by an average of 40%, and to decrease average surgical time by more than 30 minutes. There were many surgeons involved in the treatment of these cases.

Amaranath *et al* in 1975[71] reported the results of a prospective study assessing the effect of anesthesia during total hip replacement. Forty-seven patients had their blood pressure deliberately lowered 20-30% from pre-operative baseline levels. This resulted in a "markedly diminished blood loss" when

compared to the usual amount of blood loss for the procedure. Eleven patients had bilateral hip replacement and induced hypotension was employed for one side only. The second side was used as a control. Results revealed a significant reduction ($p < 0.05$) in blood loss, blood transfusion, and operative time for the side treated with hypotensive anesthesia. In cases treated with hypotensive anesthesia the authors mentioned that the dry surgical field was "much appreciated by surgical colleagues".

Lawson *et al* in 1976[72] reported on induced hypotension in patients undergoing total hip replacements. Thirteen patients were treated with controlled hypotension to a level required to dry the surgical site. The mean arterial pressure was 64 ± 4 mmHg, a 43% reduction from resting blood pressure. Five patients were treated with normotensive anesthesia. The mean arterial pressure in the normotensive group was 98 mmHg. Blood loss was measured by volumetric and gravimetric techniques. There was no indication as to how many surgeons performed the operations. All patients were supine with slight hip elevation. The surgeons were not blinded to the anesthetic technique. There was no significant difference in operative time. The average blood loss in the hypotensive group ranged from 460 to 600 ml varying with first or second operations. The average blood loss in the normotensive group was 1475 ± 200 ml. There was a total of 14 units of transfused blood in the five normotensive patients. Transfusion was instituted when blood loss approached 500 ml. There were no transfusions in the hypotensive group. Despite the fact that all of the hypotensive patients were Jehovah's Witnesses, no transfusions were physiologically indicated.

In 1977 Kerr[73] reviewed his experience with induced hypotension in 700 cases of middle ear surgery utilizing an operative microscope. Procedures included stapedectomy, myringoplasty, mastoidectomy, tympanoplasty, destruction of labyrinth and teflon shunt insertion, exploration, and middle ear reconstruction. Systolic blood pressure ranged from below 30 to above 70 mmHg. No absolute limits were reported. Head tilt was established at 10 degrees. Seventy seven percent of 280 male patients had satisfactory hemostasis. Eighty-eight percent of 420 female patients had satisfactory hemostasis. Whether more than one surgeon was involved was not identified. There were no controls in this report. Definitions of satisfactory and unsatisfactory were not established.

In 1978 Thompson *et al*[74] reported the results of a randomized study assessing blood loss and operative time in patients undergoing total hip arthroplasty. Thirty patients were involved in the study and randomly placed into one of three groups. The first group was a normotensive group with mean arterial blood pressure maintained within 20% of pre-operative levels. The second and third groups had surgical procedures performed under hypotensive anesthesia with halothane and nitroprusside respectively. Mean arterial pressure was maintained at 50 mmHg in both of the last two groups. All surgical procedures were performed by one surgeon with the patient in a lateral position. Blood pressure was measured in the normotensive group via oscillometry and via arterial line in the hypotensive groups. Blood loss was assessed by volumetric and gravimetric techniques. Mean operating time was significantly ($p < 0.05$) reduced by hypotension with no

difference between the two hypotensive groups. Blood loss was significantly less in the hypotensive groups versus the normotensive group ($p < 0.05$). The mean total amounts of blood transfused during hospitalization were: normotensive, 133 ± 200 ml, halothane hypotension, 500 ± 120 ml, and nitroprusside hypotension, 230 ± 80 ml. Ten of the 21 hypotensive patients did not need transfusion. No transfusion criteria were described. This controlled study was not blinded to the surgeon. Blood pressure was measured differently in hypotensive and normotensive groups.

In 1978 Hoshang *et al*[75] described their experience with sodium nitroprusside induced hypotension. Ten patients underwent lumbar laminectomy for removal of herniated disc and spinal fusion with autogenous iliac bone grafts. Three of these patients had previous surgery. Six patients had three level fusion and four patients had two level fusion. All patients were in a prone, bolster supported position. None of the patients required transfusion. Estimated blood loss did not exceed 200 ml. There was no control group in this study. The authors made reference to the fact that patients undergoing lumbar laminectomy and spinal fusion without hypotensive anesthesia usually required 2000 ml of blood in the perioperative period. There was no description of blood loss measurement techniques. The number of surgeons was not indicated. This was a technique report with mere reference to blood loss and transfusion requirements.

In 1979 Vazeery[76] reviewed 50 patients undergoing hip surgery. Twenty-five patients were treated with hypotensive aneshtesia and 25 patients were

treated with normotensive anesthesia. The same surgical procedure was performed on all of the patients. Intra-operative blood loss for the hypotensive group was 212 ml versus 1038 ml for the normotensive group. This was significantly different ($p < 0.001$). Post-operative blood loss was similar in both groups, but the overall blood loss remained significantly different. There were no intra-operative transfusions in the hypotensive group and the overall average amount of transfusions during the period of hospitalization was 1.6 units in the hypotensive group and 3.3 units in the normotensive group. Surgical time was reduced in the hypotensive group to a mean of 94 minutes from a normotensive mean of 110 minutes. This was significant ($p < 0.05$).

In 1980 Stirt *et al*[77] retrospectively reviewed 57 patients undergoing radical thoraco-abdominal dissection of retroperitoneal lymph nodes. All patients were male with diagnoses of testicular carcinoma of various stages. The same surgeon performed the same surgical procedures on all of the patients utilizing the same group of anesthetists. Patient position was standardized with a modified flank - 10 degree Trendelenberg. Blood loss was measured in the suction bottles and by visual inspection and estimation of sponges, drapes and tape. Allowance was made for irrigation fluid. Blood transfusion was implemented when blood loss exceeded 20% of estimated blood volume. There was no significant difference in age, weight, stage of disease, pre-operative mean arterial pressure, or hematocrit between the normotensive and hypotensive groups. Mean arterial pressure in the hypotensive group was 68 mmHg versus approximately 100 mmHg for the

normotensive group. There was a significant reduction in blood loss, 920 ± 72 ml for the hypotensive group versus 1341 ± 98 ml for the normotensive group. Twelve percent of the hypotensive group received intra-operative transfusion versus 38% in the normotensive group. The hypotensive group received an average of 0.48 units per patient versus 1.44 units per patient in the normotensive group. There was no significant difference in operative time. All variables in this report were well accounted for. However, the study was retrospective and the visual estimation of blood in sponges must be considered inaccurate even though the same for all patients.

In 1982 Quist *et al*[78] reported on a prospective, randomized, clinical trial involving 32 patients undergoing total hip replacement performed by six surgeons. One group underwent controlled hypotension and the second group was used as a control. Their results revealed twice as much blood loss in the normotensive group ($p < 0.01$), and three times the amount of blood replaced in the normotensive group ($p < 0.001$). There was no significant difference in operative time.

Grundy *et al* in 1982[79] reported a prospective, randomized, blinded to the surgeon, clinical trial assessing deliberate hypotension during spinal fusion. The hypotensive group had blood pressure levels on average 24% below baseline, whereas the "sham" hypotensive group were maintained at 9% above baseline. The surgeon and assistant were given separate questionnaires at the end of surgery and were asked to evaluate whether or not hypotensive anesthesia existed. They correctly identified hypotensive anesthesia 12 out of 13 times, and

normotensive anesthesia eight out of 11 times. There was significant reduction in blood loss ($p < 0.005$) using hypotensive anesthesia. There was no significant reduction in surgical time. Total transfusion amount was also significantly reduced ($p < 0.05$) when using controlled hypotension.

In 1983 Malcolm-Smith[80] described the surgical and anesthetic procedures for 44 patients undergoing posterior spinal fusion with Harrington rod instrumentation for idiopathic scoliosis. Twenty-one patients were subjected to hypotensive anesthesia with mean systolic blood pressure reduced from 117 to 65 mmHg. Twenty-three patients were in a non-hypotensive group with a mean systolic blood pressure reduced from a pre-operative level of 121 mmHg to an intra-operative level of 87 mmHg. The same surgeon performed the same surgical procedure on all of the patients. Intra-operative blood loss for the hypotensive group was 525 ml ± 226 versus 1530 ml ± 941 for the second group. Post-operative blood loss was 533 ml ± 267 for the hypotensive group versus 1014 ml ± 558 for the second group. The total reduction in blood loss was 2544 ± 1260 ml to 1058 ± 339 ml when using hypotension. Total transfusion requirements were reduced from 4.9 ± 2.3 units to 2.2 ± 0.9 units. They concluded that mean blood loss and transfusion requirements were significantly diminished with the use of hypotensive anesthesia.

Ahlering *et al*[81] in 1983 retrospectively reviewed the charts of 37 patients who underwent radical cystectomy for bladder cancer of varying degrees. Sixteen patients had deliberate hypotension with a blood pressure of 90/60 mmHg. There

was no documentation of the normotensive blood pressure range. Blood pressure in the hypotensive group was measured with a radial artery catheter. Only a small percentage of the normotensive patients had arterial lines. Blood pressure was otherwise measured by sphygmomanometry. All operations were performed by the same surgeon. Blood loss was measured by suction bottle contents and visual estimation of sponges. There was a significant reduction in blood loss in the hypotensive group; the normotensive group lost 1740 ± 143 ml, the hypotensive group lost 821 ± 78 ml ($p < 0.001$). Whole blood transfused to the hypotensive group (1.38 ± 0.25 units) was significantly less than for the normotensive group (3.25 ± 0.45 units) ($p < 0.05$). Ninety percent of the patients treated with normotensive anesthesia required transfusion versus 69% in the hypotensive group. Transfusion was initiated to maintain a hematocrit at 30%. There was no significant difference in operative time. They concluded that induced hypotension may be used safely in selected elderly patients requiring cystectomy and that it decreased the operative blood loss and the need for transfusion. This report was a retrospective review with no normotensive parameters. Visual estimation of blood loss must be considered inaccurate.

Simpson and Ireland in 1983[82] published a prospective study of 100 total hip replacements to compare the results of hypotensive versus normotensive anesthesia. Five surgeons performed the same standard surgical procedures. Hypotension was defined as 33% reduction form mean pre-operative systolic blood pressure. Randomization was determined by the ability to reach this 33%

reduction. The results showed that neither overall blood loss nor operative time was significantly reduced by hypotensive anesthesia. The surgeons involved agreed that hypotensive anesthesia tended to produce a dry surgical field. This was explained on the basis that although there were fewer obvious bleeding points requiring cautery, there was a continuous slow ooze of blood, insufficient to hinder the surgeon or cause an obviously saturated field. Thus, although the operating field appeared dry, the blood loss was not greatly reduced. The surgeons were not blinded to the anesthetic technique in this study. Quality of surgical field was a retrospective observation. The parameters for normotension were defined as an inability to reach a 33% reduction from baseline blood pressure. By this definition a 32% reduction in blood pressure would have been categorized as normotensive, yet this actually could have been hypotension. No absolute values were used to define hypotension or normotension.

In 1985 Patel *et al*[83] reported on a retrospective review of charts of patients who had undergone spinal fusion and Harrington rod instrumentation by the same surgeon. Twenty-seven patients had hypotensive anesthesia with systolic blood pressure reduced by 20-30 mmHg. Twenty-two patients were treated using normotensive anesthesia. There was a reduction in average blood loss by 40%, need for transfusion by 45% and surgical time by 10% in the hypotensive group. These differences were all significant ($p < 0.05$).

Saarnivaara in 1987[84] reviewed 41 patients who underwent controlled hypotensive anesthesia for middle ear microsurgery. The surgeons were not

blinded to the operative blood pressure. The quality of the surgical field was assessed using a 100 mm visual analog scale, 0 being poor and 100 representing excellent. The rating was done at the end of the case with an average of 90.7 ± 1.1 mm.

Sood *et al* in 1987[85] reported on a randomized, prospective study using induced hypotension on patients undergoing placement of lienorenal (splenorenal) shunts for portal hypertension. Eight patients had their intra-operative systolic blood pressure reduced to 90-95 mmHg. Ten patients had systolic blood pressure maintained between 100-150 mmHg. Mean blood loss was 517 ml ± 220 for the hypotensive group versus 1286 ± 523 for the normotensive group. Transfusion mean was 0.88 ± 0.9 units for the hypotensive group versus 3.0 ± 1.2 units for the normotensive group. There was a significant ($p < 0.01$) reduction in operative blood loss and requirement for transfusion when using hypotensive anesthesia.

Sataloff *et al* in 1987[86] reported on 19 patients who underwent hypotensive anesthesia for composite resections or radical neck dissections with laryngectomies and compared these patients to a retrospective control group that had undergone similar procedures. The control group was selected retrospectively to match each study patient with respect to procedure, lesion, age, ASA classification and surgeon. There was no indication if any patients received pre-operative radiotherapy. The mean arterial pressure for the hypotensive group was 55 mmHg versus 95 mmHg in the normotensive group. The mean blood loss in the normotensive group was 1369 cc versus 528 cc in the hypotensive group.

This was significantly different (p = 0.0016). This reduction in blood loss led to a significant reduction in transfusion requirements (p = 0.0026). In the normotensive group eleven patients required a total of 43 units of blood. In the hypotensive group two patients required a total of five units of blood. No transfusion criteria were documented. There was no significant reduction in surgical time (p = 0.3199). The mean operative time in the hypotensive group was 325.54 minutes ± 97.38. The mean operative time in the normotensive group was 359.76 minutes ± 111.16. The controls in this study were all retrospective. The surgeons were not blinded to the type of anesthesia. Although the cases and controls were well matched, the analysis was not reported according to procedure but rather the sum total of all procedures which were varied. Moreover, more than one surgical procedure was performed which may have altered blood loss and operative time measurement.

Hypotensive Anesthesia During Orthognathic Surgery

Schaberg *et al*[6] reviewed 13 patients who underwent surgical correction of an existing dentofacial deformity. Surgery was performed using controlled hypotensive anesthesia to a level required to create a "dry" surgical field with a minimum systolic level of 80 mmHg or mean arterial pressure of 60 mmHg. The surgical procedures included mandibular ramus osteotomies (vertical and sagittal), anterior mandibular subapical osteotomies, anterior and posterior maxillary segmental osteotomies and a LeFort I osteotomy. The patients were all positioned with 10 degree head elevation. No indication was given as to the number of

surgeons and anesthetists involved. Blood loss was measured by volumetric and gravimetric techniques as well as with chromium 51 radioisotope tagging technique. The study group was compared to a retrospective control from another center. Fourteen patients were treated using normotensive anesthesia. Surgical procedures included intra-oral and extra-oral ramus osteotomies, and maxillary and mandibular segmental osteotomies. There were no LeFort I osteotomies included in this group. The normotensive control group had a mean estimated blood loss (EBL) of 525 ± 52 ml and a mean red blood cell volume (RCV) of 456 ± 42 ml. The hypotensive study group had a mean EBL of 314 ± 57 ml and a mean RCV loss of 256 ± 35 ml. This represented a 40% and 44% reduction respectively. The mean operative time in the normotensive group was 216 ± 13.10 minutes versus 219 ± 12.83 minutes in the hypotensive group. The authors explained this fact on the basis of resident involvement and their training. They reported that the surgeons were definitely impressed, albeit subjectively, with the fact that the surgical field was drier than under normotensive anesthetic conditions.

It is very difficult to draw useful information from this study for a number of reasons. Firstly, the surgical procedures were not standardized, and they were not performed by the same surgeon. One cannot compare blood loss and operative time when a variety of surgical procedures is employed and performed by many surgeons. Secondly, blood pressure in the hypotensive group was monitored via an arterial line versus sphygmomanometry in the normotensive group. No prospective study parameters were outlined and no randomization was performed.

Lastly, the quality of the surgical field was merely observational. This cannot be appropriately assessed unless the surgeon is blinded to the anesthetic technique used and a proper ranking system is employed.

In 1980 Chan *et al*[7] reported on a controlled prospective study assessing the effect of hypotensive anesthesia on blood loss, quality of surgical field, and length of procedure involving patients undergoing anterior maxillary osteotomy using the technique described by Wunderer. Eleven patients were randomly placed into the study group. Mean arterial pressure was established at 70 mmHg. The blood pressure of the 10 control patients was allowed to vary within acceptable "safety limits". Blood pressure was monitored both by arterial cannulation and a sphygmomanometer. Blood loss was measured by volumetric and gravimetric techniques, as well as by using radio-chromium 51 tagged red cells. The quality of the surgical field was assessed at the end of surgery on a scale of one to three, one representing a relatively dry field whereas three represented an obscure, excessively bloody operative field. There was no indication as to the number of surgeons involved or whether they were blinded to the anesthetic technique. Patient posture was not documented. There was no significant difference in blood loss, quality of surgical field, or length of surgery between the study group and control group ($p < 0.05$). The authors explained this by observing that some patients in the normotensive group were actually hypotensive in relationship to their normal pre-operative blood pressures. Furthermore, some patients in the hypotensive group had operative blood pressures higher than their pre-operative

blood pressures. The data were reorganized in a manner such that the hypotensive group was defined as those patients with an operative blood pressure that was 20% below their pre-operative level, and the normotensive patients included those patients whose blood pressure was equal to or greater than their pre-operative value. Blood loss was decreased by 41% and quality of surgical field was improved by 27% in the new hypotensive group. These results were significant ($p < 0.05$).

This study was an improvement over Schaberg's report in that all of the patients had the same surgical procedure. The problem, however, was that the study became retrospective when the data were re-categorized. This introduced a level of bias into the results. Furthermore, the number of surgeons was not recorded nor was patient position. These factors definitely influenced operative time as well as hemorrhage. Finally, the quality of the surgical field was assessed by a scale that was too narrow in its parameters. Evaluation was made only at the end of the surgery and there was no indication as to whether the surgeon was blinded to the blood pressure level.

In 1982 Washburn and Hyer[87] retrospectively reviewed their experience with deliberate hypotension for 58 elective major maxillofacial surgery cases. The procedures included orthognathic surgery, preprosthetic surgery, reconstructive oral and maxillofacial surgery, and surgical resection for osseous pathosis. Each operative procedure was carried out by attending surgeons together with resident surgeons. Systolic blood pressure was maintained at a level of 80 $\pm$ 5 mmHg to

the point where the majority of soft tissue and osseous cuts had been made. Patients were all placed in a supine position with a head-up tilt that varied from 15 25 degrees. Lidocaine 1% with epinephrine 1:200 000 was also used to assist with hemostasis. They concluded that deliberate hypotension reduced blood loss and operating time during elective major maxillofacial surgery. One patient required transfusion. However, this was necessary to treat an existing pre-operative anemia. When reviewing operative time, the authors categorized similar operations to establish average operative time for similar procedures. It is important to note that many surgeons were involved in these procedures which may have altered surgical time. Furthermore, instrument passing and usual operative delays were not accounted for. In addition, the variation in head tilt may have altered the degree of bleeding at the operative site. The use of epinephrine for hemostasis could also have altered the overall effectiveness of hypotension. There was no indication as to actual measurement of blood loss. Assessment was made by comparing pre-operative hemoglobin and hematocrit to post-operative values. It was not indicated as to when the post-operative measurement was made. Intravenous fluids could have affected these values. Finally, this was a retrospective review and there were no controls.

In 1986 Fromme *et al*[88] reported on a prospective study designed to determine whether controlled hypotensive anesthesia resulted in a statistically significant difference in the surgeon's perception of the quality of the surgical field. Fifty-six patients, undergoing maxillary and mandibular osteotomies, were

randomized into one of three groups. Group one was a normotensive group with mean arterial pressure maintained between 90-100 mmHg. Group two had a mean arterial pressure maintained at 75-85 mmHg. Group three represented the hypotensive group with mean arterial pressures ranging from 55-60 mmHg. Blood pressure was monitored with a radial artery catheter. The surgical team was blinded to the type of anesthesia employed. The surgical site was assessed at half hour intervals based on a numerical scale of 0 to 5.

0 = minimal bleeding, very dry field

1 = mild bleeding, but no interference with dissection

2 = moderate bleeding, nuisance in regard to the surgical field, but no actual compromise of the ability to dissect

3 = moderate bleeding, modest compromise of the surgical field

4 = heavy but controllable bleeding, significant interference with dissection

5 = massive uncontrollable bleeding

All patients were positioned supine with 15 degree head elevation. The surgeon was the same for all cases. The authors found no significant difference in the quality of the surgical field, blood loss, or operative times among the three groups.

This report introduced a new scale of evaluation with a broader range and more specific descriptions than that used in Chan's study. An improvement was made in the frequency of evaluation times. It is worthy to note, however, that the evaluations of the surgical field were not correlated with the blood pressure at that point in the operation. The assumption was made that a smooth blood pressure

level was maintained throughout the surgical procedure with no rise at times of stimulation. Furthermore, no error study was performed on this scale to identify if a score of "2" in one patient was the same as "2" in the next patient. Since there were differences in the surgical procedures and no indication was made as to whether the maxilla was segmentalized or whether the mandibular ramus osteotomy was sagittal or vertical, variabilities were introduced into the measurement of blood loss and surgical time.

In 1987 McNulty *et al*[89] retrospectively reviewed his experience with Labetalol induced hypotension during orthognathic surgery. Ten patients were included in the study. When significant surgical bleeding was expected, the blood pressure was reduced to a mean arterial pressure of 55-60 mmHg. When surgical bleeding was no longer a problem the blood pressure was returned to baseline value. The authors reported a mean blood loss of 399 ± 142 ml. No patients required transfusion. Mean post-operative hemoglobin was 11.2 ± 1 versus a pre-operative mean of 12.7 ± 1. The lowest post-operative value was 9.2. The authors concluded that the measured blood loss and pre-operative/post-operative hemoglobin levels were indicative of satisfactory operative conditions and since no patient had required a blood transfusion, the goals of producing induced hypotension had been achieved. However, in this retrospective review, there were no controls, no description was given as to how blood loss was measured, and no transfusion criteria were identified. Although all patients underwent orthognathic surgery, there was no documentation as to the type of surgery. There was no

record of surgical time, or the quality of the surgical field to evaluate objectively the effectiveness of induced hypotension. The number of surgeons involved and patient position were not documented.

Lessard *et al* in 1989[90] reported on a prospective study to evaluate the ability of deliberate hypotension to reduce blood loss, improve the surgical field, and decrease operative time in orthognathic surgery. Fifty-two patients were randomized either to a hypotensive group with mean arterial pressure maintained at 55-65 mmHg or to a normotensive group in which patients were treated with a mean arterial pressure of 75-85 mmHg. Blood pressure was monitored by a radial artery catheter. All patients had LeFort I osteotomies along with a mandibular osteotomy. Three surgeons performed the operations and they were blinded to the anesthetic technique. Patient head position was standardized at 15 degree elevation. The surgeons infiltrated lidocaine 2% with 1:100 000 epinephrine into the mucosa prior to incision. Blood loss was measured by volumetric and gravimetric techniques and surgical field was assessed using Fromme's numerical scale.[88] The surgical field was evaluated during mucosal dissection and again during the osteotomy.

There was no statistically significant difference in operative time. There was a significant ($p < 0.001$) reduction in blood loss (40%) and need for transfusion. Three of 25 hypotensive patients required transfusion versus 12 of 27 normotensive patients. Transfusions were started when estimated blood loss exceeded 20% of estimated blood volume. The surgical field was rated significantly better in the hypotensive group.

It is important to note a number of facts. Firstly, there was no error study performed on the scale of evaluation. However, the surgeons were more specific as to the times of evaluation. Secondly, three surgeons were involved in the operations which could have altered all variables measured. Furthermore, local anesthetic with vasoconstrictor, although used in both groups, could have altered the proposed benefit of hypotensive anesthesia. In addition, surgical procedures may have varied. They were only identified as LeFort I osteotomies along with mandibular osteotomies. Maxillary segmentalization along with either vertical or sagittal osteotomies of the mandibular ramus could have made a difference when comparing one group to the other.

In all of the preceding studies,[6,7,87-90] two factors that were not accounted for were the variability in electrocautery setting and the delay in instrument transfer during operation. These factors may have an effect on blood loss, the quality of the surgical field and the length of the surgical procedure.

MATERIALS AND METHODS

A randomized, prospective, blinded-to-the-surgeon, clinical trial was designed to test the hypothesis that hypotensive anesthesia was better than normotensive anesthesia when comparing intra-operative blood loss, the surgeon's perception of the quality of the surgical field and operative time during LeFort I osteotomies.

Treatment Groups

Group I consisted of those patients who underwent hypotensive anesthesia during which the mean arterial blood pressure (MAP)* was maintained between 50-60 mmHg with a systolic blood pressure less than 80 mmHg.

Group II consisted of those patients who had normotensive anesthesia during which blood pressure was maintained at a "normal" pre-operative value as determined by average ward values. All pre-operative blood pressures were measured by the nursing staff using manual sphygmomanometry. The measurements were performed three times the evening pre-operatively and one time the morning of surgery. An average of these four blood pressure recordings was used as the "normal" pre-operative value.

Inclusion Criteria

1. Male or female patients between the ages of 14-60 undergoing an orthognathic surgical procedure that included a LeFort I osteotomy.
2. Patients designated as American Society of Anesthesiology category I or II.

* MAP = diastolic blood pressure + $\left(\frac{\text{systolic blood pressure} - \text{diastolic blood pressure}}{3}\right)$

Exclusion Criteria

1. History of previous cerebrovascular accident.
2. Coronary artery disease.
3. History of heart failure.
4. Peripheral vascular disease.
5. Respiratory insufficiency.
6. Abnormal liver function.
7. Abnormal kidney function.
8. Gross anemia.

Sample Size

The study was designed to have 20 patients in each of the two groups, but data were to be analyzed after 50% of patients in each group were studied to determine if there was a statistically significant difference between the two groups with respect to blood loss, and if so, the study would be terminated. The O'Brien-Fleming criterion[91] would then be used to correct the significance level for multiple comparison. This study was approved by the Clinical Trials Committee of the Montreal General Hospital.

Randomization

Patients were assigned on a random basis to either Group I or Group II with an effort made to achieve an equal number of male and female patients in each group. Only the anesthetist was aware to which group the patient had been assigned. The surgeon was blinded to the anesthetic technique and to the patients' blood pressures.

Pre-operative Protocol

Patients were admitted to the Oral and Maxillofacial Surgery service at the Montreal General Hospital one day prior to surgery. Each patient underwent a full history review, physical examination, and internal medicine consultation. Each patient had pre-operative tests that included a urinalysis, complete blood count, electrolytes, renal and liver profile, glucose, and electrocardiogram.

Operative Protocol

One anesthesia team was involved with all of the cases utilizing a standardized technique. All patients were prepared as if undergoing hypotensive anesthesia. The physical anesthesia set-up was identical for both groups. The anesthetist established a blood pressure level depending on the patient group. Once the anesthetist felt that he had an adequate, stable blood pressure, he instructed the surgeon to initiate a painful stimulus on the patient for 30 seconds by applying a sharp periosteal elevator into the periodontal ligament of the patient's tooth. This was done in order to determine if the blood pressure was controlled, or if it was necessary to make further adjustments.

A designated Oral Surgery resident, not involved in the surgical procedure, was responsible for videotaping the surgical procedures, recording intra-operative data, and measuring the blood loss. The video camera was positioned and maintained above the surgical site throughout the surgical procedure.

Surgical Technique

All patients underwent LeFort I osteotomies by the same surgical team in a standardized sequence. The surgical team included two separate attending surgeons and the same surgical assistant. The surgical procedure was divided between the attending surgeon and the assistant. One side was performed by the attending surgeon and the other side was performed by the assistant surgeon in an alternating fashion in the exact same manner, with the exact same instruments. The attending surgeon began the procedure. A mucosal incision was made from the first molar area and extended to the midline. The incision was made approximately 5 mm above the mucogingival junction. The incision was made with an electrocautery knife to the level of, but not including the periosteum. The same electrocautery unit was used in all of the cases, with the same setting. The periosteum was then incised with a number 15 surgical scalpel blade. A subperiosteal plane was then established from the pyriform rim and tunnelled posteriorly to the pterygoid plate. A moistened gauze was then placed into this tunnel. The same procedure was then carried out on the opposite side of the maxilla.

The nasal mucosa was then dissected from the floor of the nose on side one followed by side two.

A drill with a 701 tapered fissure bur was then used to make registration marks 5 mm above the apices of the cuspid and first molar teeth. This was performed bilaterally.

The lateral wall of the maxilla was osteotomized at the level of the registration marks with a reciprocating saw. In the posterior region the osteotomy was completed with a fine osteotome and mallet to the level of the pterygoid plate. This was performed bilaterally.

The lateral wall of the nose was osteotomized with a guarded Silver osteotome to the level of the perpendicular plate of the palatine bone. Right and left sides were done in sequence. The nasal septum was then osteotomized with a guarded nasal septum osteotome. This completed the study period from the start of the mucosal incision to just after the nasal septum osteotomy.

Anesthetic Method

All patients were premedicated with morphine 10 mg and atropine 0.6 mg intra-muscularly one hour before induction of anesthesia. On arrival in the operating room the patients' nostrils were anesthetized and vasoconstricted with 1 ml of 1% neosynephrine in 4 ml of 4% lidocaine, and intravenous and radial arterial lines were inserted under local anesthesia. A pulse oximeter was placed and electrocardiogram leads were applied. All patients were catheterized and urine flow was monitored. Anesthesia was induced with propofol 2 mg/kg, sufentanyl 0.5 mg/kg, and vecuronium 20 mg to facilitate nasal endotracheal intubation. Anesthesia was maintained with propofol 3 mg/kg/hr, sufentanyl 0.5 mg/kg/hr, and isoflurane 0.5% in 100% oxygen. All patients were ventilated to maintain an end-tidal carbon dioxide of 35-40 mmHg. Before surgery began, each patient received a further 10 mg of vecuronium to ensure complete neuromuscular blockade during the study.

To optimize venous drainage from the surgical site, the operating table was flexed and the head elevated so that the angle of the mandible was above the heart and at the level of the sternal angle. To ensure a constant and consistent hydrostatic zero reference point for arterial blood pressure measurement, one end of a flexible spirit-level was attached to the patient's head at the level of the surgical site, and the other end to the blood pressure transducer stand. All blood pressures, therefore, were referenced to the surgical site and not to the heart level at the mid-axillary line.

Those patients in the hypotensive group were infused with 300 mg of labetalol over 15 minutes, beginning immediately after endotracheal intubation. Both groups were maintained at their target blood pressure until the test stimulation. Even when there was no response to this test, the surgical incision produced a marked increase in blood pressure. Therefore, immediately following the test stimulation, the isoflurane concentration was increased to 2-3%, and when the blood pressure began to fall below the target level, surgery was started. During the study period the blood pressure was maintained at the target level by altering the isoflurane concentration, and the infusions of propofol and sufentanyl remained unchanged.

After the study was completed the sufentanyl infusion was reduced to 0.1 mg/kg/hr and discontinued ten minutes before the end of surgery. Neuromuscular blockade was reversed with pyridostigmine 10 mg and atropine 0.6 mg, and the patient was transferred to the recovery room intubated, breathing spontaneously and responding to commands.

Evaluation

Three separate factors were evaluated: length of the surgical procedure, blood loss and the quality of the surgical field.

Length of the Surgical Procedure

The length of the surgical procedure was measured by means of the videotape from the point of mucosal incision to just after the nasal septum osteotomy. All instrument passing delays and video positioning delays were eliminated from the surgical time. The time measurement was performed by one surgical resident unaware of the study groups.

Blood Loss

Sponges and throat packs were weighed prior to the start of the operations. Two empty suction tubings and a connector as well as the empty suction bottles were weighed at the start of the operations. All irrigating fluid was dispensed via 60 cc syringes graduated in milliliter increments. The amount of fluid required to moisten the sponges and the amount of fluid used in the oral cavity were recorded. All of the sponges, the tubing and connector, the suction bottle and the throat pack were weighed again at the end of the study period. The pre-operative weights and volumes were subtracted from the post-operative value to yield a measured surgical blood loss. The standard 1 cc = 1 g was used for these measurements.

Quality of the Surgical Field

The quality of the surgical field was assessed intra-operatively by the attending surgeon at predetermined surgical intervals. Assessments were made during and after 11 surgical steps thus producing 22 reference intervals (Table 1). The assessment after each of the designated surgical steps was made two seconds after removal of the suctioning device from the surgical field. The quality of the surgical field was scored by the amount of bleeding present using the following scale:

5 = massive bleeding; cannot carry out dissection

4 = severe bleeding; significantly compromises dissection

3 = moderate bleeding; slightly compromises dissection

2 = mild bleeding; a nuisance but does not compromise dissection

1 = minimal bleeding; not a surgical nuisance

An intra-operative blood pressure and heart rate were recorded corresponding to each of the 22 reference points.

Upon completion of the study the videotapes were reviewed by a third party (Evaluator II) unaware of the study groups and unaware of Evaluator I scores. This was done on two separate occasions to verify intra-evaluator and inter-evaluator reproducibility. On the second occasion, Evaluator II remained blinded to operative blood pressure, Evaluator I scores and his own initial scores. When all data were compiled there existed three scores for each of the 22 reference points along with a corresponding blood pressure and heart rate.

Table 1

Time	Evaluator I*	Evaluator II**		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)							
After incision (1)							
During flap retraction (1)							
After flap retraction (1)							
During incision (2)							
After incision (2)							
During flap retraction (2)							
After flap retraction (2)							
During nasal dissection (1)							
After nasal dissection (1)							
During nasal dissection (2)							
After nasal dissection (2)							
During maxil. osteotomy (1)							
After maxil. osteotomy (1)							
During maxil osteotomy (2)							
After maxil osteotomy (2)							
During lat. nasal osteotomy (1)							
After lat. nasal osteotomy (1)							
During lat nasal osteotomy (2)							
After lat nasal osteotomy (2)							
During septal osteotomy							
After septal osteotomy							

* Evaluator I was the surgeon in the operating room

** Evaluator II was another surgeon who reviewed the video tapes on two separate occasions blinded to the anesthetic technique and to both his first scores and Evaluator I scores.

RESULTS

Pre-operative Data

The two treatment groups were compared on pre-operative characteristics using independent group t-test for continuous variables and χ^2 test for categorical variables. Comparisons were made for age, weight, pre-operative blood pressure (systolic and mean arterial pressure), and sex (see Table 2). The difference between the normotensive and hypotensive groups with respect to age, sex, weight and pre-operative mean arterial pressure (MAP) was very small and definitely non-significant. Although the pre-operative systolic blood pressure showed a marginally significant difference between the two groups, after correcting for multiple comparisons, this difference should be considered as non-significant. Accordingly, one may conclude that there was no statistically significant or clinically important difference in all pre-operative characteristics between the two groups.

Operative Data

The two treatment groups were compared on treatment effects using independent group t-test for continuous variables and χ^2 test for categorical variables. Comparisons were made for intra-operative blood pressure (systolic and mean arterial pressure [MAP]), surgical time, operative blood loss, lacerated nasal mucosa, and transected descending palatine vessels (see Table 3). There was a very statistically significant difference between the two groups in operative blood pressure but no statistically significant differences in surgical time, percentage of lacerated nasal mucosa, and percentage of transected descending palatine vessels.

Table 2 Pre-operative Data

Variable	Normotensive n = 12 mean SD	Hypotensive n = 11 mean SD	Test of Difference (p value)
Age (yr)	27.7 ± 10.0	24.5 ± 5.8	0.37
Weight (kg)	66.0 ± 10.1	73.2 ± 16.3	0.21
Pre-op systolic blood pressure (mmHg)	113.3 ± 8.9	120.9 ± 8.0	0.04
Pre-op MAP (mmHg)	87.8 ± 7.0	89.4 ± 5.9	0.56
Sex	50%	55%	0.83

Table 3 Operative Data

Variable	Normotensive n = 12 mean SD	Hypotensive n = 11 mean SD	Test of Difference (p value)
Intra-op systolic blood pressure (mmHg)	119.7 ± 7.1	76.3 ± 5.9	0.0001
Intra-op MAP (mmHg)	86.6 ± 4.9	50.2 ± 2.1	0.0001
Surgical time (min.sec)	13.9 ± 3.1	12.7 ± 3.8	0.44
Blood loss (ml)	270.2 ± 153.6	120.3 ± 70.4	0.008
% palatine vessels transected	50%	43%	1.0
% nasal mucosa lacerated	53%	33%	0.64

The difference in blood loss was assessed using t-test with correction for unequal variances. The difference was found to be highly statistically significant ($t = 3.02$, $df = 16$, $p < 0.01$) and met the O'Brien-Fleming criterion[91] for the first of the two sequential tests. This provided reliable evidence of the advantage of hypotensive anesthesia in terms of reducing blood loss. One patient in the hypotensive group was eliminated for blood loss measurement because blood lost from an iliac donor site was not separated from the blood lost during the LeFort I osteotomy.

The reliability of scoring was assessed looking at both intra-evaluator and inter-evaluator correlation and by estimating the distribution of the absolute difference between corresponding ratings.

There was evidence of highly statistically significant correlation both between two ratings of the same observer ($r = 0.76$, $p < .0001$) and between ratings of two different evaluators ($r = 0.62$, $p < .0001$). However, the intra-evaluator reliability was higher.

The two means of the same evaluator were very similar (1.87 versus 1.78). However, there was a very systematic difference between the mean ratings yielded by two evaluators (2.53 versus 1.87 for the first measurement of Evaluator II).

Analysis of the distribution of absolute differences between corresponding ratings confirmed greater consistency of intra-evaluator measurements (Evaluator II, A and B), versus measurements yielded by two evaluators (Evaluator I versus Evaluator II). In 63% of cases the corresponding ratings generated by Evaluator II

were identical, while a perfect agreement by the different evaluators was only 39%. Discrepancy larger than one unit was observed in only 0.2% (one single instance) for Evaluator II's scores but in 15% of cases between evaluators. Because of these results, the average between both Evaluator II scores for each stage was used to assess the correlation between evaluator's scores and the intra-operative blood pressure.

The correlation between the evaluator's scores and the blood pressure was assessed by using a random-effects model for correlated outcomes.[92] Dependence of measure was accounted for due to the fact that for each patient there was a series of 22 measurements. The analysis was carried out using BMDP 5V procedure for longitudinal data. The correlation between the score and both the systolic blood pressure and mean arterial pressure was very highly statistically significant; MAP (wald χ^2 statistics: 67.8, 1 d.f., $p < 0.0001$), systolic (χ^2 = 54.4, 1 d.f., $p < 0.0001$). On average, one unit increase in the evaluator's score was associated with 8.7 mmHg increase in the mean arterial pressure and 10.3 mmHg increase in systolic blood pressure.

DISCUSSION

Deliberate, controlled, hypotensive anesthesia has been employed during surgical procedures in an attempt to reduce operative hemorrhage and the resultant need for transfusion. It is claimed to improve the quality of the surgical field and reduce operative time.[5-90]

The use of hypotensive anesthesia is not a new technique, but rather has been reviewed to a large extent in general surgical procedures. Reports have been mostly anecdotal and observational case reviews along with retrospective reports. A few true prospective controlled studies have been reported.[12 86]

Most dentofacial deformities can be corrected with maxillary and/or mandibular osteotomies performed by an intra-oral approach.[3] It is generally agreed that the head and neck area, especially the oral cavity, is a highly vascular region. Intra-oral osteotomies present a limited access approach and bleeding during surgery may compound visibility. A reduction in surgical hemorrhage would seem to be desirable in that it may improve the quality of the surgical field making dissection easier and faster. Furthermore, a decrease in hemorrhage may result in a reduced need for transfusion.[3,6 9 90]

The use of hypotensive anesthesia in orthognathic surgery would therefore seem appropriate and has been reported in the literature.[6,7,87 90] The existing studies have either been poorly controlled or have involved dissimilar study groups with respect to a number of variables. Results have been conflicting.

It was hypothesized that hypotensive anesthesia during a LeFort I osteotomy

results in decreased blood loss, decreased operative time, and improved quality of the surgical field as compared to normotensive anesthesia.

In an attempt to clarify the value of hypotensive anesthesia a prospective, randomized, blinded to the surgeon, clinical trial was performed using either hypotensive or normotensive anesthesia on patients undergoing LeFort I osteotomies.

The results of this study revealed a statistically significant reduction in operative blood loss when using hypotensive anesthesia, a very highly statistically significant correlation between the surgeon's perception of the quality of the surgical field and intra-operative blood pressure, and no statistically significant decrease in operative time when using hypotensive anesthesia. These results are of more significant value than those in previous studies due to the more rigid control of intra-operative variables and the utilization of video imaging.

Schaberg *et al*[6] reported a reduction in blood loss, no change in operative time and an improved surgical field when using hypotensive anesthesia. Their results were in agreement with the results of this study. However, in their study surgical procedures were varied including many types of maxillary and mandibular osteotomies. This factor in itself made comparisons of blood loss and operative time inaccurate. Inaccuracy was compounded by the fact that the control group was retrospective and selected from another center. Furthermore, blood pressure in the normotensive group was measured by sphygmomanometry whereas in the hypotensive group it was measured via a radial artery catheter. This factor may

have altered the actual differences in blood pressures when comparing one group to the other. The quality of the surgical field was merely observational at the end of the study period. No prospective parameters were outlined. The blood pressure in the study group was reduced to a level required to "dry" the surgical field. The surgical field cannot be appropriately assessed unless the surgeon is blinded to the anesthetic technique and intra-operative blood pressure, and a proper rating system is employed.

In their study, Chan *et al*[7] made improvements in the study design. They reported on a controlled, randomized, prospective study assessing the effects of hypotensive anesthesia on blood loss, quality of the surgical field and the length of the surgical procedure. All of the patients underwent anterior maxillary osteotomy using the technique described by Wunderer. The blood pressure parameters were prospectively outlined for each group and blood pressure was measured with both an arterial line and blood pressure cuff in all patients. They introduced a rating scale of 1 to 3 to assess the quality of the surgical field. All of the above can be considered improvements by Chan and his team over the previous report by Schaberg *et al*. However, the study was not without flaws. They failed to document the number of surgeons involved, patient posture and whether the surgeon was blinded to the anesthetic technique and intra-operative blood pressure. These factors are important in that the patient's posture will influence bleeding and if not standardized will alter the results. Furthermore, many surgeons, and particularly if not standardized in their techniques, sequence of

procedures, and instrumentation, could affect all measurements. In addition, a rating scheme is of value, but only if it is used at appropriate times, made by one evaluator and that evaluator blinded to the patient's blood pressure. Lastly, the rating scale used was too narrow in its parameters and may have obscured greater or lesser differences between normotension and hypotension.

Initial review of their data revealed no significant difference ($p < 0.05$) in blood loss, quality of surgical field, or length of surgery when the hypotensive group was compared to the control group. The authors explained this by observing that some patients in the normotensive group were actually hypotensive in relationship to their normal pre-operative blood pressure. Furthermore, some patients in the hypotensive group had operative blood pressures higher than their pre-operative blood pressures. The data were reorganized in a manner such that the hypotensive group was redefined as being those patients with an operative blood pressure that was 20% below their pre-operative level, and the normotensive group as being those whose blood pressure was equal to or greater than their pre-operative value. The new data revealed significant reduction ($p < 0.05$) in blood loss and the quality of the surgical field when using hypotensive anesthesia. There was no difference in operative time. These results, although concurring with the results of this study, were biased by the fact that the study became retrospective when the data were re-categorized.

Fromme *et al*[88] in their study made further improvements to the previous reports. They described a randomized, prospective, blinded to the surgeon, clinical

study to determine whether controlled, hypotensive anesthesia resulted in a statistically significant difference in the surgeon's perception of the quality of the surgical field, operative blood loss, and operative time. Patients were randomized into one of three groups, which included a hypotensive, normotensive and intermediate group. In their study the surgeon was blinded to operative blood pressure and the same surgeon performed all of the operations. A broader scale from 0 to 5 was introduced and rating was done at half hour intervals. All patients were positioned with standardized 15 degree head elevation. They reported no significant differences in operative time, blood loss, and the quality of the surgical field among the three groups.

Despite these improvements, the study design was still somewhat flawed. Although the operative site was evaluated at more frequent intervals, the moments of evaluation were not correlated with the blood pressure at that specific point in the operation. The assumption was made that a smooth blood pressure level was maintained throughout the surgical procedure with no fluctuation. Furthermore, no error study was performed on this scale to identify if a score of "3" in one patient was the same as "3" in the next patient. They only identified their surgical procedures as maxillary and mandibular osteotomies. However, it must be recognized that these procedures can vary and because of this variability this can introduce considerable error with respect to blood loss and operative time. The final issue is that of the 15 degree head elevation. It is important to note that there is a reduction of 2 mmHg for every inch of vertical height above which the

blood pressure is recorded.[93] Therefore, with 15 degree head elevation as used in Fromme's study, blood pressure at the operative site would have been approximately 10-12 mmHg less than at the level of the heart. One can therefore see that the groups in Fromme's study were actually treated at a blood pressure less than that which was reported and thus more patients were actually hypotensive. This may explain the reason why no differences were detected among the groups.

Lessard *et al*[90] also reported on a prospective, randomized, blinded to the surgeon, clinical trial assessing the same three entities as in the preceding study. Their study design was the same as that of Fromme with minor variations. They only had two study groups with a narrow difference in blood pressure parameters (hypotensive: MAP of 55-65 mmHg; normotensive: MAP of 75-85 mmHg). Three surgeons were involved in the operations. The surgeons infiltrated lidocaine 2% with 1:100 000 epinephrine into the mucosa prior to incision. They used Fromme's numerical scale to rate the operative field but did so at specific points in the operation, viz. mucosal incisions and osteotomy cuts. The authors found no significant reduction in operative time, a significant reduction in blood loss, and a significant improvement in the quality of the surgical field when using hypotensive anesthesia. The results were similar to those of this study. The problems with their study were many. Firstly, surgical procedures may have varied. They were only identified as LeFort I osteotomies. No indication was made as to whether or not segmentalization was performed. This could alter surgical time and blood loss.

Secondly, three surgeons were involved in the operations. This can alter surgical time and assessment of the quality of the surgical field due to lack of inter-evaluator reliability. Thirdly, the use of epinephrine as a vasoconstrictor could have altered the effects of hypotensive anesthesia. Lastly, the 15 degree head elevation placed the control group close to the hypotensive range.

Because of the flaws in the previous mentioned studies, an attempt was made to develop a study design to control for as many variables as possible. In this study the hypotensive and normotensive parameters were prospectively defined. Patients were randomly placed into one of two groups. The surgeon was blinded to the anesthetic technique and intra-operative blood pressure. Two surgeons performed the operations along with the same surgical assistant. This may be viewed as a weakness in the study design. However, the surgical technique was standardized with respect to procedure, sequence, and instrumentation, and was strictly adhered to. Surgical time was measured on a videotape and it was therefore possible to eliminate unnecessary instrument passing delays that may have altered the surgical time in previous studies.

No statistically significant difference was demonstrated in operative time when using hypotensive versus normotensive anesthesia. This was a rather interesting finding. One would have assumed that if the surgical field were improved that the operation could be carried out more quickly. It was interesting to observe on the video tapes that when bleeding was brisk that the dissection was carried out rapidly in order to get bleeding under control, whereas, when the

field was dry the dissection was carried out in a slow, controlled, deliberate manner.

The surgical procedure in this study was well defined. LeFort I osteotomies were performed on all patients from the mucosal incision up to and including the nasal septum osteotomy. Restricting the study period to this stage might be criticized as hemorrhage may occur or may continue during and after down fracture of the maxilla. However, it was felt that the mucosal incisions and osteotomy cuts were representative of both hard and soft tissue surgery and therefore adequate to test the hypothesis.

Blood loss was measured by volumetric and gravimetric techniques similar to Fromme and Lessard. Strict attention was directed to the amount of irrigation used. In this study the same surgical procedure, with definite starting and ending points, was performed in all patients. This lent itself to a true comparison of blood loss.

Another important factor in this study was the use of the video imaging technique. On its simplest level this allowed for a measure of operative time as described. More importantly, operative fields could be analyzed and ranked by a separate evaluator blinded to the anesthetic technique and blood pressure. This study used Fromme's numerical scale with very slight modification by eliminating the "0" category and by slightly modifying the definitions that made the groups more distinct for the evaluators involved. Evaluator II rated the video tapes on two separate occasions to investigate the reliability of the numerical scores. The

second evaluator was unaware of Evaluator I scores or his own initial scores. These scores were also compared to the intra-operative scores to assess inter-evaluator reliability. It was determined that the intra-evaluator reliability was higher than the inter-evaluator reliability. In fact, the scores of the operating surgeon were consistently higher than those of the second evaluator. Perhaps this could be explained on the basis that the rating carried out during the surgery is influenced by the pressure and anxiety of the procedure itself. Evaluations carried out by an individual not involved in the surgery by using the video are free from this pressure and therefore can be viewed as more objective.

Each score corresponded to a specific surgical period and a corresponding blood pressure. This permitted an accurate correlation between the perception of the surgical field and the specific blood pressure at that time. This took into account fluctuations in blood pressure, such that if for some reason the blood pressure rose in a hypotensive patient, it would in theory be reflected with an increase in the evaluator's score. This was indeed the case. A one unit increase in score was associated with a systolic pressure increase of 10.3 mmHg and a mean arterial pressure increase of 8.7 mmHg.

All of the patients were positioned supine with the table flexed so that the head was elevated to a level that placed the angle of the mandible above the heart. However, all blood pressure recordings (by radial artery catheter) were referenced to the operative site by use of a flexible spirit-level. This eliminated the variable introduced by the head-up position.[93]

None of the previous studies commented on the use or setting of the electrocautery unit. A higher setting of the cautery may alter bleeding. In this study the same cautery unit was used with the same setting on all patients.

Laceration of the nasal mucosa during the dissection along the floor of the nose can result in an increase in bleeding. Furthermore, transection of the descending palatine vessels could also result in an increase in hemorrhage. These factors were documented and found to be not significantly different between the two groups. Furthermore, no vasoconstrictor was used in this study.

SUMMARY AND CONCLUSION

It was hypothesized that hypotensive anesthesia was better than normotensive anesthesia during LeFort I osteotomies when comparing blood loss, operative time, and the quality of the surgical field.

A prospective, randomized, blinded to the surgeon, clinical trial was designed to compare hypotensive versus normotensive anesthesia with respect to the foregoing.

Twenty-three patients were randomized into one of two groups: 12 in the normotensive group (mean systolic pressure: 119.7 ± 7.1; mean MAP: 86.6 ± 4.9) and 11 in the hypotensive group (mean systolic pressure: 76.3 ± 5.4; mean MAP: 50.2 ± 2.1). There was no statistically significant difference when correcting for multiple comparisons in pre-operative characteristics.

A video imaging model was developed to assess operative time and the quality of the surgical field. The video tapes allowed for assessment of inter- and intra-operator reliability with respect to surgical score. Intra-evaluator reliability was greater and more consistent.

There was no statistically significant reduction ($p < 0.44$) in operative time when using hypotensive anesthesia.

There was a statistically significant reduction ($p < .01$) in blood loss, as measured by volumetric and gravimetric techniques, when using hypotensive anesthesia.

There was a very highly statistically significant correlation ($p < .0001$) between operative blood pressure and the surgeon's perception of the quality of the surgical field.

On the basis of these results it is concluded that hypotensive anesthesia is valuable during LeFort I osteotomies in reducing blood loss and improving the quality of the surgical field, thus allowing for easier, more deliberate, careful dissection, even though it does not reduce operative time.

Further studies are needed to determine if by introducing the variable of a vasoconstrictor it further improves the benefits of hypotensive anesthesia or, if used in conjunction with normotensive anesthesia, eliminates the need for controlled hypotension.

BIBLIOGRAPHY

1. Proffit, W.R., White Jr., R.P. "The need for surgical orthodontic treatment." In: Surgical-Orthodontic Treatment (Proffit, W.R., White Jr., R.P., eds), p 2. Mosby Year Book Inc., 1991.

2. Caldwell, J.B., Gerhard, R.C., Lowry, R.E. "Orthognathic surgery." In: Textbook of Oral and Maxillofacial Surgery (Kruger, G.O., ed.), p 515. The C.V. Mosby Company, 1984.

3. Tucker, M.R., White Jr., R.P. "Principles of surgical management for dentofacial deformity." In: Surgical-Orthodontic Treatment (Proffit, W.R., White Jr., R.P., eds.), p 229. Mosby-Year Book, Inc., 1991.

4. Kelly, J.F., Terry, B.C. Blood volume changes in the surgical treatment of oral-facial deformities: a preliminary report. J. Oral Surg. 31:90, 1973.

5. Anderson, J.A. Deliberate hypotensive anesthesia for orthognathic surgery: controlled pharmacologic manipulation of cardiovascular physiology. Int. J. Adult Orthod. Orthog. Surg. 1:133, 1986.

6. Schaberg, S.J. *et al.* Blood loss and hypotensive anesthesia in oral-facial corrective surgery. J. Oral surg. 34:147, 1976.

7. Chan, W., Smith, D.E., Ware, W.H. Effects of hypotensive anesthesia in anterior maxillary osteotomy. J. Oral Surg. 38:504, 1980.

8. Gallagher, D.M., Milliken, R.A. Induced hypotension for orthgnathic surgery. J. Oral Surg. 37:47, 1979.

9. Golia, J.K., Woo, R., Farole, A., Seitzer, J.-L. Nitroglycerin-controlled circulation in orthognathic surgery. J. Oral Maxillofac. Surg. 43:342, 1985.

10. McIndoe, A. Hypotensive anesthesia in surgery. Plast. Reconstr. Surg. 17:1, 1956.

11. Sollevi, A., Hypotensive anesthesia and blood loss. Acta Anaesthesiol. Scand. 32:39, 1988.

12. Gardner, W.J. The control of bleeding during operation by induced hypotension. J.A.M.A. 132:572, 1946.

13. Harris, H.E., Hale, D.E. Induced hypotension in the control of bleeding during the fenestration operation. Cleve. Clin. Quart. 14:159, 1947.

14. Hale, D.E. Controlled hypotension by arterial bleeding during operation and anesthesia. Anesthesiology 9:498, 1948.

15. Griffiths, H.W.C., Gillies, J. Thoraco-lumbar splanchnicectomy and sympathectomy. Anaesthesia 3:134, 1948.

16. Enderby, G.E.H. Controlled circulation with hypotensive drugs and posture to reduce bleeding in surgery. Lancet 258:1145, 1950.

17. Enderby, G.E.H., Pelmore, J.F. Controlled hypotension and postural ischemia to reduce bleeding in surgery. Lancet 260:663, 1951.

18. Hughes, G. Use of pentamethonium and posture to reduce bleeding in fenestration operations. Lancet 260:666, 1951.

19. Lewis, I. Value of hypotensive drugs in minimizing blood loss in thoracic surgery. Lancet 261:150, 1951.

20. Shackleton, R.P.W. The reduction of surgical hemorrhage. Br. Med. J. 1:1054, 1951.

21. Bilsland, W.L. Controlled hypotension by arteriotomy in intracranial surgery. Anaesthesia 6:20, 1951.

22. Rycroft, B.W., Romanes, G.I. Preliminary report on the use of methonium compounds and general anesthesia in ophthalmologic surgery. Br. J. Ophthalmology 36:29, 1952.

23. Boyan, C.P., Brunschwig, A. Hypotensive anesthesia in radical pelvic and abdominal surgery. Surgery 31:829, 1952.

24. Korkis, F.B. Discussion on the use of hypotensive drugs in surgery. Proc. Roy. Soc. Med. 44:838, 1951.

25. Stammers, F.A.R. Discussion on hypotension during anesthesia. Proc. Roy. Soc. Med. 46:605, 1953.

26. Langston, K.W. Controlled hypotension to reduce surgical haemorrhage. Can. Med. Assoc. J. 69:371, 1953.

27. Cox, R. Discussion on hypotension during anesthesia. Proc. Roy. Soc. Med. 46:608, 1953.

28. James, A., Coulter, R.L., Saunders, J.W. Controlled hypotension in neurosurgery with special reference to hypotension induced by suction applied to the legs. Lancet 264:412, 1953.

29. Anderson, S., McKissock, W. Controlled hypotension with arfonad in neurosurgery. Lancet 265:754, 1953.

30. Nicholson, M.J., Sarnoff, S.J., Crehan, J.P. The intravenous use of a thiophanium derivative for the production of flexible and rapidly reversible hypotension during surgery. Anesthesiology 14:215, 1953.

31. Stevens, R.J.M., Tovell, R.M. Hexamethonium salts as an aid to the orthopedic surgeon. J.A.M.A. 154:402, 1954.

32. Kilduff, C. The use of arfonad in controlled hypotension. Lancet 1:337, 1954.

33. Scurr, C.F., Wyman, J.B. Controlled hypotension with arfonad. Lancet 1:338, 1954.

34. Mandow, G.A., Arden, G.P., Stoneham, F.J.R. Hypotension induced with hexamethonium bromide during anesthesia. Br. J. Anaesth. 26:26, 1954.

35. Stirling, J.B. Anesthesia with hypotension for fenestration. Br. J. Anaesth. 27:80, 1955.

36. Safar, P. A study of deliberate hypotension in anesthesia with special consideration of surgical blood loss in comparable groups of normotensive and hypotensive anesthesia. Surgery 37:1002, 1955.

37. Mazzia, V.D.B., Ray, B.S., Artusio, J.F. Induced hypotension as an aid to intracranial surgery. J.A.M.A. 161:1240, 1956.

38. Royster, H.P., Ditzler, J.W. The use of controlled hypotension in operations of the head and neck. Plast. Reconstr. Surg. 17:9, 1956.

39. Holmes, F. Induced hypotension in orthopaedic surgery. J. Bone Joint Surg. 38B:846, 1956.

40. Ditzler, J.W., Eckenhoff, J.E. A comparison of blood loss and operative time in certain surgical procedures completed with and without controlled hypotension. Ann. Surg. 143:289, 1956.

41. Cox, R. Hypotensive anesthesia. Br. J. Urol. 29:362, 1957.

42. Jacobs, A. General discussion. Br. J. Urol. 29:386, 1957.

43. Walters, G.A.B. General discussion. Br. J. Urol. 29:387, 1957.

44. Shepperd, N.L. General discussion. Br. J. Urol. 29:388, 1957.

45. Scott, D.B. Anesthesia for radical hysterectomy. Anaesthesia 13:19, 1958.

46. Tomskey, G., Bray, K., Adriani, J. The use of hypotensive anesthesia to control bleeding during nephrolithotomy. Southern Med. J. 51:52, 1958.

47. Bodman, R. Blood loss during prostatectomy. Br. J. Anaesth. 31:484, 1959.

48. Gusterson, F.R. Halothane in the closed circuit. Anaesthesia 14:35, 1959.

49. Murtagh, G.P. Controlled hypotension with halothane. Anaesthesia 15:235, 1960.

50. Moersh, R.N., Patrick, R.T., Clagett, O.T. The use of hypotensive anesthesia in radical mastectomy. Ann. Surgery 152:911, 1960.

51. Bruce, A.W., Zorab, D.A., Still, B. Blood loss in prostatic surgery. Br. J. Urol. 32:422, 1960.

52. Riches, E. General discussion. Br. J. Urol. 32:427, 1960.

53. Jacobs, A. General discussion. Br. J. Urol. 32:427, 1960.

54. Holloway, K.B., Holmes, F., Hider, C.F. Guanethidine in hypotensive anesthesia. Clinical study in patients undergoing microsurgery of the middle ear. Br. J. Anaesth. 33:648, 1961.

55. Linacre, J.L. Induced hypotension in gynaecological surgery. A review of 1000 major cases. Br. J. of Anaesth. 33:45, 1961.

56. Hayward-Butt, J.T., Kos, C.M. Induced hypotension in the conscious patient during endaural surgery. Anesth. Analg. 41:279, 1962.

57. Chamberlin, J.A., Mannheimer, W.H. Hypotensive anesthesia in radical surgery of the head and neck. Plast. Reconstr. Surg. 31:316, 1963.

58. Baker, A.H. Prostatectomy and hypotensive anesthesia. Proc. Roy. Soc. Med. 57:1179, 1964.

59. Boreham, P. Retropubic prostatectomy with hypotensive anesthesia. Proc. Roy. Soc. Med. 57:1181, 1964.

60. Slade, N., Andrews, G.L., Tovey, G.H., Wilson, F. Blood loss in prostatic surgery. Br. J. Urol. 36:399, 1964.

61. Eckenhoff, J.E., Rich, J.C. Clinical experiences with deliberate hypotension. Anesth. Analg. 45:21, 1966.

62. Smith, D.L., Didier, E.P., Clagett, O.T. Controlled hypotension in radical mastectomy. Ann. Surg. 2:263, 1966.

63. Sleath, G.W., Archer, L.T. Halothane for controlled hypotension in back surgery. Can. Anaesth. Soc. J. 14:407, 1967.

64. Donald, J.R. The effect of anesthesia, hypotension and epidural analgesia on blood loss in surgery for pelvic floor repair. Br. J. Anaesth. 41:155, 1969.

65. Taylor, T.H., Styles, M., Lamming, J. Sodium nitroprusside as a hypotensive agent in general anesthesia. Br. J. Anaesth. 42:859, 1970.

66. Deacock, A.R. Aspects of anesthesia for middle ear surgery and blood loss during stapecectomy. Proc. Roy. Soc. Med. 64:1226, 1971.

67. Jennings, J.J., Davis, N., Harris, W.H. Controlled hypotensive anesthesia. J. Bone and Joint Surg. 55-A:1313, 1973.

68. Mallory, T.H. Hypotensive anesthesia in total hip replacement. JAMA 224:248, 1973.

69. Davis, N.J., Jennings, J.J., Harriss, W.H. Induced hypotensive anesthesia for total hip replacement. Clin. Orthop. Rel. Res. 101:93, 1974.

70. McNeill, T.W., Dewald, R.L., Kuo, K.N., Bennett, E.J., Salem, M.R. Controlled hypotensive anesthesia in scoliosis surgery. J. Bone Joint Surg. 56A:1964, 1974.

71. Amaranath, L., Cascorbi, H.F., Singh-Amaranath, A.V., Frankmann, D.B. Relation of anesthesia to total hip replacement and control of operative blood loss. Anesth. Analg. 54:641, 1975.

72. Lawson, N.W., Thompson, D.S., Nelson, C.A., Flacke, J.W., North, E.R. Sodium nitroprusside-induced hypotension for supine total hip replacement. Anesth. Analg. 55:654, 1976.

73. Kerr, A.R. Anesthesia with profound hypotension for middle ear surgery. Br. J. Anaesth. 49:477, 1977.

74. Thompson, G.E., Miller, R.D., Stevens, W.C., Murray, W.R. Hypotensive anesthesia for total hip arthroplasty. A study of blood loss and organ function. Anesthesiology 48:91, 1978.

75. Hoshang, J. Hypotensive anesthesia for spinal fusion with sodium nitroprusside. Spine 3:171, 1978.

76. Vazeery, A.K., Lunde, O. Controlled hypotension in hip joint surgery. An assessment of surgical hemorrhage during sodium nitroprusside infusion. Acta Orthoped. Scand. 50:433, 1979.

77. Stirt, J.A., Korn, E.L., Reynolds, R.C. Sodium nitroprusside-induced hypotension in radical thoraco-abdominal dissection of retroperitoneal lymph nodes. Br. J. Anaesth. 52:1045, 1980.

78. Quist, T.F., Skousted, P., Bredgaard-Sorensen, M. Moderate hypotensive anesthesia for reduction of blood loss during total hip replacement. Acta Anaesthiol. Scand. 26:351, 1982.

79. Grundy, B.L., Nash, C.L., Brown, R.H. Deliberate hypotension for spinal fusion: prospective randomized study with evoked potential monitoring. Can. Anaesth. Soc. J. 29:452, 1982.

80. Malcolm-Smith, W.A., McMaster, M.J. The use of induced hypotension to control bleeding during posterior fusion for scoliosis. J. Bone Joint Surg. 65B:255, 1983.

81. Ahlering, T.E., Henderson, J.B., Skinner, D.G. Controlled hypotensive anesthesia to reduce blood loss in radical cystectomy for bladder cancer. J. Urol. 129:953, 1983.

82. Simpson, D.A., Ireland, J. Hypotensive and normotensive anesthesia in total hip replacement. Br. J. Clin. Pract. 31:16, 1983.

83. Patel, N.J., Patel, B.S., Paskin, S., Laufer, S. Induced moderate hypotensive anesthesia for spinal fusion and Harrington rod instrumentation. J. Bone Joint Surg. 67A:1384, 1985.

84. Saarnivaara, L., Klemola, U.-M., Lundgren, L. Labetalol as a hypotensive agent for middle ear microsurgery. Acta Anaesthiol. Scand. 31:196, 1987.

85. Sood, S., Jayalaxmi, T.S., Vijayaraghavan, S., Nundy, S. Use of sodium nitroprusside induced hypotensive anesthesia for reducing blood loss in patients undergoing lienorenal shunts for portal hypertension. Br. J. Surg. 74:1036, 1987.

86. Sataloff, R.T., Brown, A.C.D., Sheets, E.E., Rubinstein, M.I. A controlled study of hypotensive anesthesia in head and neck surgery. Ear, Nose

87. Washburn, M.C., Hyer, R.L. Deliberate hypotension for elective major maxillofacial surgery: A balanced halothane and morphine technique. J. Maxillofacial Surg. 10:50, 1982.

88. Fromme, G.A., MacKenzie, R.A., Gould, A.B., Lund, B.A., Offord, K.P. Controlled hypotension for orthognathic surgery. Anesth. Analg. 65:683, 1986.

89. McNulty, S., Sharifi-Azad, S., Farole, A. Induced hypotension with labetalol for orthognathic surgery. J. Oral & Maxillofac. Surg. 45:309, 1987.

90. Lessard, M.R., Trepanier, C.A., Baribault, J.P., Brochu, J.G., Brousseau, C.A., Coté, J.J., Denault, P.H. Isofurane-induced hypotension in orthognathic surgery. Anesth. Analg. 69:379, 1989.

91. O'Brien, P.C., Fleming, T.R. A multi-stage procedure for clinical trials. Biometrics B5:549, 1979.

92. Laird, N.M., Ware, J.H. Random effects models for longitudinal data. Biometrics 38:963, 1982.

93. Lawson, A.G. Deliberate hypotension. Anesthesiology 25:683, 1964.

APPENDIX A:

INTRA-OPERATIVE DATA

Table 1 Patient 2

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	1	2	2	74	44	52	73
After incision (1)	3	2	2	75	48	55	76
During flap retraction (1)	2	2	2	79	52	58	76
After flap retraction (1)	1	2	2	62	41	46	72
During incision (2)	2	2	2	59	41	46	73
After incision (2)	3	1	2	63	40	47	74
During flap retraction (2)	3	2	2	67	41	49	75
After flap retraction (2)	3	1	1	68	45	51	76
During nasal dissection (1)	2	1	2	67	42	50	76
After nasal dissection (1)	1	1	2	60	40	46	76
During nasal dissection (2)	1	1	2	59	39	45	75
After nasal dissection (2)	3	1	2	54	37	43	76
During maxil. osteotomy (1)	1	1	1	71	46	54	78
After maxil osteotomy (1)	2	1	1	70	44	52	77
During maxil. osteotomy (2)	2	2	2	72	45	52	78
After maxil osteotomy (2)	2	1	1	70	44	52	77
During lat nasal osteotomy (1)	2	1	1	67	44	51	79
After lat nasal osteotomy (1)	3	1	1	74	46	53	79
During lat nasal osteotomy (2)	2	1	2	72	45	52	79
After lat nasal osteotomy (2)	3	1	2	71	44	53	79
During septal osteotomy	3	2	2	76	47	56	78
After septal osteotomy	3	1	2	77	49	59	79

Table 2 Patient 4

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	3	2	3	108	60	81	77
After incision (1)	3	3	2	100	54	64	78
During flap retraction (1)	3	3	2	94	50	67	82
After flap retraction (1)	3	1	1	89	45	65	79
During incision (2)	2	1	2	83	39	55	76
After incision (2)	2	1	2	84	40	57	75
During flap retraction (2)	3	2	1	78	36	51	77
After flap retraction (2)	2	1	1	76	35	50	77
During nasal dissection (1)	2	1	1	76	33	46	75
After nasal dissection (1)	2	2	1	73	32	46	75
During nasal dissection (2)	2	1	1	76	33	48	74
After nasal dissection (2)	2	2	1	76	34	47	73
During maxil. osteotomy (1)	2	1	1	77	35	50	74
After maxil osteotomy (1)	3	1	2	74	33	49	73
During maxil. osteotomy (2)	2	1	1	77	35	51	72
After maxil. osteotomy (2)	2	1	2	77	35	51	72
During lat. nasal osteotomy (1)	1	1	1	87	40	55	71
After lat. nasal osteotomy (1)	1	1	1	81	38	55	70
During lat. nasal osteotomy (2)	1	1	1	77	35	50	74
After lat. nasal osteotomy (2)	1	1	1	77	34	50	72
During septal osteotomy	1	1	1	88	42	57	71
After septal osteotomy	2	2	1	88	42	57	71

Table 3 Patient 7

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	2	2	2	84	42	56	74
After incision (1)	3	2	2	85	45	58	76
During flap retraction (1)	3	2	2	82	43	56	80
After flap retraction (1)	3	2	2	80	45	56	86
During incision (2)	3	1	2	81	45	56	81
After incision (2)	4	2	2	83	45	58	80
During flap retraction (2)	3	1	1	81	44	56	81
After flap retraction (2)	4	1	2	78	41	53	80
During nasal dissection (1)	1	2	2	73	38	48	81
After nasal dissection (1)	2	1	2	70	35	46	81
During nasal dissection (2)	3	2	2	67	33	44	80
After nasal dissection (2)	3	1	2	69	34	46	78
During maxil. osteotomy (1)	1	1	1	65	32	44	80
After maxil osteotomy (1)	2	1	1	68	33	44	75
During maxil. osteotomy (2)	2	1	1	74	37	50	80
After maxil. osteotomy (2)	2	1	1	74	37	49	78
During lat. nasal osteotomy (1)	1	1	1	73	36	48	82
After lat. nasal osteotomy (1)	1	1	1	74	36	49	81
During lat. nasal osteotomy (2)	1	1	1	73	36	48	83
After lat. nasal osteotomy (2)	2	1	1	74	37	49	83
During septal osteotomy	1	1	1	77	39	52	82
After septal osteotomy	2	1	1	81	41	52	81

Table 4 Patient 8

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	2	1	2	83	38	65	71
After incision (1)	3	2	3	86	39	58	74
During flap retraction (1)	3	2	2	90	40	51	75
After flap retraction (1)	2	1	2	86	40	42	77
During incision (2)	3	1	2	79	35	39	79
After incision (2)	3	2	2	86	38	37	80
During flap retraction (2)	3	2	2	84	37	38	77
After flap retraction (2)	4	1	2	82	36	39	76
During nasal dissection (1)	1	2	1	77	33	53	74
After nasal dissection (1)	3	1	2	78	37	53	73
During nasal dissection (2)	2	1	2	78	35	49	70
After nasal dissection (2)	2	2	1	74	34	50	68
During maxil osteotomy (1)	2	1	1	76	34	49	71
After maxil osteotomy (1)	3	1	1	75	33	51	71
During maxil osteotomy (2)	3	1	1	76	30	51	69
After maxil osteotomy (2)	1	1	1	72	32	51	69
During lat. nasal osteotomy (1)	2	1	1	71	31	49	71
After lat. nasal osteotomy (1)	2	1	1	73	33	49	70
During lat nasal osteotomy (2)	2	1	1	78	35	49	71
After lat nasal osteotomy (2)	2	1	1	76	35	50	70
During septal osteotomy	2	1	1	76	35	49	72
After septal osteotomy	3	2	2	86	43	50	71

Table 5 Patient 9

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	2	2	2	76	39	50	80
After incision (1)	2	2	2	82	41	53	79
During flap retraction (1)	2	2	2	87	46	59	77
After flap retraction (1)	2	1	2	79	40	52	76
During incision (2)	3	2	2	84	44	55	79
After incision (2)	3	2	2	83	43	55	79
During flap retraction (2)	2	2	2	77	41	52	79
After flap retraction (2)	2	1	1	79	41	52	78
During nasal dissection (1)	3	2	2	70	39	48	76
After nasal dissection (1)	2	2	2	72	33	51	77
During nasal dissection (2)	2	1	2	64	36	47	75
After nasal dissection (2)	2	1	2	63	36	47	75
During maxil. osteotomy (1)	2	1	2	71	35	46	75
After maxil. osteotomy (1)	3	2	2	70	36	48	76
During maxil. osteotomy (2)	3	2	1	70	40	51	78
After maxil. osteotomy (2)	3	1	2	74	44	59	78
During lat. nasal osteotomy (1)	1	1	1	77	47	58	77
After lat. nasal osteotomy (1)	2	1	1	77	47	57	76
During lat. nasal osteotomy (2)	1	1	1	77	47	57	79
After lat. nasal osteotomy (2)	1	1	2	81	42	55	76
During septal osteotomy	1	1	1	77	37	48	74
After septal osteotomy	3	1	1	71	34	47	77

Table 6 Patient 13

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	1	1	1	98	43	60	86
After incision (1)	2	2	1	101	46	64	85
During flap retraction (1)	2	2	2	98	46	63	87
After flap retraction (1)	2	2	2	98	44	62	86
During incision (2)	2	1	2	101	45	62	87
After incision (2)	2	2	2	90	30	57	90
During flap retraction (2)	3	1	2	95	41	58	89
After flap retraction (2)	2	1	1	90	41	59	90
During nasal dissection (1)	2	1	1	66	22	35	88
After nasal dissection (1)	1	1	1	59	21	33	88
During nasal dissection (2)	2	1	1	69	27	37	88
After nasal dissection (2)	2	2	2	69	27	37	88
During maxil. osteotomy (1)	1	1	1	77	27	40	85
After maxil osteotomy (1)	1	1	1	68	24	36	84
During maxil osteotomy (2)	1	1	1	71	27	38	85
After maxil osteotomy (2)	1	1	1	68	25	36	83
During lat nasal osteotomy (1)	1	1	1	81	29	44	81
After lat. nasal osteotomy (1)	1	1	1	82	29	43	80
During lat nasal osteotomy (2)	1	1	1	80	28	41	81
After lat. nasal osteotomy (2)	4	3	3	73	26	40	81
During septal osteotomy	3	2	2	105	43	64	79
After septal osteotomy	3	2	1	87	34	52	81

Table 7 Patient 14

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	3	1	2	98	54	66	75
After incision (1)	3	2	2	97	50	64	75
During flap retraction (1)	1	1	1	73	31	44	77
After flap retraction (1)	1	1	1	72	29	41	77
During incision (2)	2	1	2	73	29	41	77
After incision (2)	3	2	2	74	30	43	78
During flap retraction (2)	1	1	1	74	34	46	77
After flap retraction (2)	1	1	1	76	36	46	76
During nasal dissection (1)	1	1	1	77	37	48	76
After nasal dissection (1)	1	1	1	74	30	49	76
During nasal dissection (2)	1	1	1	79	43	52	76
After nasal dissection (2)	2	1	1	79	41	51	76
During maxil. osteotomy (1)	1	1	1	66	34	45	75
After maxil. osteotomy (1)	1	1	1	70	37	46	75
During maxil. osteotomy (2)	1	1	1	70	37	47	75
After maxil. osteotomy (2)	1	1	1	69	37	47	75
During lat nasal osteotomy (1)	1	1	1	67	37	46	75
After lat. nasal osteotomy (1)	1	1	2	72	39	48	75
During lat. nasal osteotomy (2)	1	1	1	73	41	50	75
After lat. nasal osteotomy (2)	1	1	1	65	34	45	75
During septal osteotomy	2	1	1	70	39	48	74
After septal osteotomy	2	1	1	75	43	51	74

Table 8 Patient 15

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	2	2	2	81	43	56	72
After incision (1)	4	3	3	88	53	58	74
During flap retraction (1)	2	2	2	93	58	69	77
After flap retraction (1)	2	2	2	78	48	58	78
During incision (2)	2	2	2	78	47	57	78
After incision (2)	2	2	2	80	47	57	79
During flap retraction (2)	2	2	1	70	41	52	78
After flap retraction (2)	2	1	1	61	37	47	78
During nasal dissection (1)	1	2	1	48	30	37	76
After nasal dissection (1)	2	2	2	49	31	38	76
During nasal dissection (2)	1	1	1	60	40	47	78
After nasal dissection (2)	1	1	1	6[illegible]	40	47	78
During maxil osteotomy (1)	1	1	1	6[illegible]	42	51	77
After maxil osteotomy (1)	1	1	1	60	39	48	76
During maxil osteotomy (2)	1	1	1	62	41	50	77
After maxil osteotomy (2)	1	1	1	65	42	50	77
During lat nasal osteotomy (1)	1	1	1	52	35	43	76
After lat nasal osteotomy (1)	1	1	1	53	36	48	76
During lat nasal osteotomy (2)	1	1	1	54	36	43	77
After lat nasal osteotomy (2)	1	1	1	56	37	45	77
During septal osteotomy	1	1	1	60	39	48	77
After septal osteotomy	1	1	1	60	39	48	77

Table 9 Patient 16

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	3	3	2	82	34	46	70
After incision (1)	3	3	2	77	31	43	70
During flap retraction (1)	4	3	2	91	39	50	65
After flap retraction (1)	3	2	2	90	38	51	66
During incision (2)	4	3	2	82	34	45	68
After incision (2)	4	3	2	82	34	45	68
During flap retraction (2)	4	3	2	80	34	46	70
After flap retraction (2)	4	3	2	81	35	48	70
During nasal dissection (1)	4	3	3	79	31	44	71
After nasal dissection (1)	4	3	3	79	32	44	71
During nasal dissection (2)	4	3	2	82	35	47	68
After nasal dissection (2)	4	3	2	84	34	47	68
During maxil. osteotomy (1)	4	2	2	92	37	50	67
After maxil. osteotomy (1)	4	3	2	87	36	50	68
During maxil. osteotomy (2)	3	2	1	89	37	52	66
After maxil. osteotomy (2)	2	1	1	91	38	53	66
During lat nasal osteotomy (1)	2	1	1	101	42	57	66
After lat nasal osteotomy (1)	4	3	3	91	39	55	68
During lat. nasal osteotomy (2)	2	1	1	102	45	64	66
After lat nasal osteotomy (2)	3	2	1	100	40	58	68
During septal osteotomy	4	2	2	100	44	59	70
After septal osteotomy	4	2	3	99	42	60	71

Table 10 Patient 19

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	2	2	1	92	52	65	90
After incision (1)	3	2	1	84	45	58	88
During flap retraction (1)	1	1	1	74	39	51	88
After flap retraction (1)	1	1	1	63	32	42	82
During incision (2)	1	1	1	60	29	39	77
After incision (2)	1	1	1	55	27	37	74
During flap retraction (2)	2	1	1	58	28	38	75
After flap retraction (2)	2	1	1	60	29	39	74
During nasal dissection (1)	1	1	1	80	40	53	76
After nasal dissection (1)	1	1	1	79	40	53	76
During nasal dissection (2)	2	1	2	72	38	49	76
After nasal dissection (2)	2	1	1	74	38	50	74
During maxil osteotomy (1)	1	1	1	73	37	49	73
After maxil osteotomy (1)	1	1	1	76	38	51	71
During maxil osteotomy (2)	1	1	1	76	38	51	74
After maxil osteotomy (2)	1	1	1	75	38	51	73
During lat nasal osteotomy (1)	1	1	1	71	33	49	72
After lat nasal osteotomy (1)	1	1	1	76	38	49	73
During lat nasal osteotomy (2)	1	1	1	74	36	49	73
After lat. nasal osteotomy (2)	1	1	1	74	38	50	73
During septal osteotomy	1	1	1	75	37	49	73
After septal osteotomy	1	1	1	74	38	50	72

Table 11 Patient 21

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	3	3	3	118	64	82	64
After incision (1)	4	3	3	114	59	77	66
During flap retraction (1)	4	4	4	131	73	92	70
After flap retraction (1)	5	4	4	107	55	72	70
During incision (2)	4	3	3	123	67	86	76
After incision (2)	5	3	4	111	61	78	68
During flap retraction (2)	3	4	4	122	67	85	73
After flap retraction (2)	5	4	4	120	68	85	77
During nasal dissection (1)	3	4	4	114	59	77	77
After nasal dissection (1)	5	3	4	115	60	78	74
During nasal dissection (2)	3	4	4	118	61	80	71
After nasal dissection (2)	5	4	4	108	55	73	75
During maxil osteotomy (1)	3	3	3	133	72	92	73
After maxil osteotomy (1)	5	3	3	131	70	90	66
During maxil. osteotomy (2)	3	3	3	136	72	93	71
After maxil osteotomy (2)	5	4	4	126	67	87	73
During lat. nasal osteotomy (1)	4	3	3	129	66	87	75
After lat. nasal osteotomy (1)	4	3	3	119	61	80	73
During lat. nasal osteotomy (2)	3	3	2	119	62	80	77
After lat. nasal osteotomy (2)	4	3	3	134	72	92	73
During septal osteotomy	3	3	3	115	58	78	73
After septal osteotomy	5	3	2	141	76	98	77

Table 12 Patient 22

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	3	2	2	85	38	54	71
After incision (1)	3	2	2	80	35	50	72
During flap retraction (1)	3	3	4	96	45	62	72
After flap retraction (1)	4	3	3	93	43	60	72
During incision (2)	3	3	2	80	38	52	75
After incision (2)	4	3	3	83	39	54	77
During flap retraction (2)	3	3	3	87	40	56	77
After flap retraction (2)	3	3	3	82	39	53	77
During nasal dissection (1)	2	3	3	68	31	43	77
After nasal dissection (1)	2	3	3	70	31	44	77
During nasal dissection (2)	3	3	3	66	29	41	75
After nasal dissection (2)	2	3	2	66	30	42	75
During maxil. osteotomy (1)	2	2	2	65	28	40	70
After maxil osteotomy (1)	3	2	2	73	31	45	71
During maxil. osteotomy (2)	3	2	2	76	34	48	71
After maxil. osteotomy (2)	2	2	3	75	33	47	68
During lat nasal osteotomy (1)	1	2	2	68	30	43	68
After lat nasal osteotomy (1)	2	2	2	72	31	45	68
During lat nasal osteotomy (2)	1	2	2	70	31	44	69
After lat nasal osteotomy (2)	2	3	2	72	31	45	68
During septal osteotomy	2	3	2	79	33	48	66
After septal osteotomy	2	2	2	75	33	47	67

Table 13 Patient 1

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	2	3	2	123	71	89	84
After incision (1)	2	3	2	119	70	86	82
During flap retraction (1)	1	3	2	136	86	103	85
After flap retraction (1)	1	2	2	138	86	103	86
During incision (2)	2	3	2	129	79	97	88
After incision (2)	2	3	2	126	78	96	88
During flap retraction (2)	2	2	1	139	87	106	91
After flap retraction (2)	2	2	1	134	83	103	91
During nasal dissection (1)	2	2	1	137	84	104	96
After nasal dissection (1)	2	3	2	133	82	102	95
During nasal dissection (2)	2	2	1	130	78	96	95
After nasal dissection (2)	2	2	1	127	77	95	95
During maxil osteotomy (1)	3	2	1	126	76	93	105
After maxil osteotomy (1)	3	2	1	124	74	90	105
During maxil osteotomy (2)	3	1	1	133	82	98	112
After maxil. osteotomy (2)	3	1	1	133	77	95	114
During lat nasal osteotomy (1)	3	1	1	125	72	90	110
After lat. nasal osteotomy (1)	3	1	1	123	71	87	110
During lat nasal osteotomy (2)	3	1	1	119	68	84	108
After lat nasal osteotomy (2)	2	1	1	121	66	82	108
During septal osteotomy	3	2	1	128	76	93	112
After septal osteotomy	3	2	2	129	73	91	112

Table 14 Patient 3

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	2	2	2	130	69	93	69
After incision (1)	3	2	2	121	63	88	69
During flap retraction (1)	3	2	2	132	70	97	70
After flap retraction (1)	3	1	1	145	76	104	72
During incision (2)	3	1	2	137	78	100	68
After incision (2)	4	2	2	147	79	103	69
During flap retraction (2)	4	2	1	135	71	98	72
After flap retraction (2)	2	1	1	139	74	98	71
During nasal dissection (1)	1	1	1	134	64	97	67
After nasal dissection (1)	2	2	2	127	64	92	66
During nasal dissection (2)	2	2	2	124	64	85	68
After nasal dissection (2)	2	2	2	119	61	83	66
During maxil osteotomy (1)	1	1	1	125	64	86	64
After maxil osteotomy (1)	1	1	1	120	60	82	64
During maxil osteotomy (2)	1	1	1	134	72	95	60
After maxil osteotomy (2)	1	1	1	134	69	95	62
During lat nasal osteotomy (1)	1	1	1	125	64	88	62
After lat nasal osteotomy (1)	1	1	2	122	63	85	61
During lat nasal osteotomy (2)	1	1	1	121	62	86	64
After lat nasal osteotomy (2)	1	1	1	121	62	86	64
During septal osteotomy	1	1	1	131	68	90	63
After septal osteotomy	1	1	1	132	69	91	63

Table 15 Patient 5

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	3	1	1	121	64	88	74
After incision (1)	3	2	1	125	66	91	63
During flap retraction (1)	3	3	3	131	73	97	64
After flap retraction (1)	4	3	1	121	66	94	63
During incision (2)	4	2	2	151	80	110	53
After incision (2)	4	3	2	139	76	105	66
During flap retraction (2)	4	3	3	136	75	103	70
After flap retraction (2)	4	3	2	127	71	98	71
During nasal dissection (1)	3	3	3	117	65	90	73
After nasal dissection (1)	5	3	3	115	63	88	70
During nasal dissection (2)	4	4	3	112	61	85	73
After nasal dissection (2)	5	4	4	100	52	75	70
During maxil osteotomy (1)	1	1	1	107	56	77	73
After maxil. osteotomy (1)	3	2	2	120	59	80	68
During maxil osteotomy (2)	2	1	1	114	63	86	75
After maxil osteotomy (2)	3	2	2	127	70	96	76
During lat nasal osteotomy (1)	2	1	2	92	50	68	73
After lat. nasal osteotomy (1)	3	2	3	121	58	82	68
During lat nasal osteotomy (2)	2	1	2	115	62	79	71
After lat. nasal osteotomy (2)	3	2	2	98	50	71	70
During septal osteotomy	2	2	2	118	74	95	74
After septal osteotomy	4	3	3	122	64	93	72

Table 16 Patient 6

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	3	3	3	122	70	92	86
After incision (1)	4	3	3	120	69	89	81
During flap retraction (1)	3	2	2	125	72	92	89
After flap retraction (1)	2	2	2	121	69	92	87
During incision (2)	4	3	2	117	66	85	95
After incision (2)	4	3	3	117	66	85	97
During flap retraction (2)	4	4	3	122	71	88	104
After flap retraction (2)	2	1	1	119	68	86	102
During nasal dissection (1)	2	2	2	99	54	73	114
After nasal dissection (1)	2	2	1	99	50	68	111
During nasal dissection (2)	2	3	3	99	58	73	108
After nasal dissection (2)	3	2	2	95	53	70	105
During maxil. osteotomy (1)	2	2	1	120	70	88	85
After maxil. osteotomy (1)	2	1	1	106	56	81	81
During maxil osteotomy (2)	2	1	1	124	77	86	83
After maxil. osteotomy (2)	1	2	1	111	62	87	86
During lat. nasal osteotomy (1)	2	1	1	121	74	88	99
After lat. nasal osteotomy (1)	2	1	2	123	74	92	90
During lat. nasal osteotomy (2)	3	2	2	125	74	92	91
After lat nasal osteotomy (2)	3	2	3	127	72	94	90
During septal osteotomy	3	1	1	131	77	100	92
After septal osteotomy	2	2	2	124	69	97	85

Table 17 Patient 10

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	3	4	3	142	84	110	103
After incision (1)	5	3	3	145	86	114	112
During flap retraction (1)	3	3	2	146	86	114	110
After flap retraction (1)	5	3	2	151	92	115	112
During incision (2)	4	3	3	139	82	110	115
After incision (2)	5	4	3	139	81	109	103
During flap retraction (2)	5	4	3	131	75	98	102
After flap retraction (2)	4	3	3	115	62	83	107
During nasal dissection (1)	2	2	2	110	57	79	104
After nasal dissection (1)	4	2	2	107	55	75	98
During nasal dissection (2)	3	3	2	115	59	78	96
After nasal dissection (2)	4	3	2	110	57	75	91
During maxil. osteotomy (1)	2	2	1	119	60	82	85
After maxil. osteotomy (1)	3	2	1	113	58	81	83
During maxil. osteotomy (2)	2	3	2	135	71	94	85
After maxil. osteotomy (2)	3	3	2	123	64	90	82
During lat. nasal osteotomy (1)	3	2	2	119	61	83	85
After lat. nasal osteotomy (1)	2	2	1	127	67	90	84
During lat. nasal osteotomy (2)	2	1	1	112	69	79	88
After lat. nasal osteotomy (2)	2	1	1	131	71	93	84
During septal osteotomy	3	3	2	127	67	91	80
After septal osteotomy	2	2	1	127	65	92	83

Table 18 Patient 11

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	3	3	2	126	71	86	51
After incision (1)	3	2	2	126	71	86	50
During flap retraction (1)	4	3	2	134	73	93	43
After flap retraction (1)	3	2	1	131	69	89	43
During incision (2)	4	3	2	139	84	97	52
After incision (2)	4	3	2	130	71	90	59
During flap retraction (2)	4	3	2	133	71	93	60
After flap retraction (2)	3	3	2	139	73	93	56
During nasal dissection (1)	3	3	1	131	73	91	63
After nasal dissection (1)	3	3	3	131	73	91	63
During nasal dissection (2)	3	3	2	124	68	88	65
After nasal dissection (2)	4	3	3	125	69	88	65
During maxil. osteotomy (1)	3	2	1	114	62	77	63
After maxil. osteotomy (1)	1	1	1	109	62	74	59
During maxil. osteotomy (2)	4	4	3	120	63	82	64
After maxil. osteotomy (2)	2	3	1	98	54	76	67
During lat. nasal osteotomy (1)	1	3	2	104	57	71	64
After lat. nasal osteotomy (1)	1	2	1	101	54	69	63
During lat. nasal osteotomy (2)	3	2	1	121	70	82	63
After lat. nasal osteotomy (2)	3	3	2	113	62	80	67
During septal osteotomy	3	3	2	123	71	84	64
After septal osteotomy	3	3	2	112	64	84	64

Table 19 Patient 12

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	3	2	3	117	78	91	123
After incision (1)	3	2	2	113	73	89	125
During flap retraction (1)	2	2	1	130	79	91	129
After flap retraction (1)	3	1	2	112	72	87	129
During incision (2)	4	3	3	105	64	79	131
After incision (2)	4	3	3	107	63	78	130
During flap retraction (2)	3	2	2	107	63	79	129
After flap retraction (2)	3	2	2	104	61	77	128
During nasal dissection (1)	2	1	2	105	60	76	127
After nasal dissection (1)	2	1	1	105	59	75	125
During nasal dissection (2)	3	2	2	107	64	78	122
After nasal dissection (2)	2	2	1	107	64	78	121
During maxil. osteotomy (1)	2	1	1	116	73	90	115
After maxil. osteotomy (1)	2	1	1	110	70	85	114
During maxil. osteotomy (2)	2	1	1	127	81	97	117
After maxil. osteotomy (2)	2	1	2	115	73	91	118
During lat. nasal osteotomy (1)	2	1	1	116	73	91	117
After lat. nasal osteotomy (1)	1	1	2	114	92	87	117
During lat. nasal osteotomy (2)	2	1	1	129	82	96	117
After lat. nasal osteotomy (2)	2	1	2	122	76	92	117
During septal osteotomy	2	1	1	120	78	90	118
After septal osteotomy	2	1	1	121	77	95	117

Table 20 Patient 18

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	3	2	2	97	56	74	70
After incision (1)	3	2	2	100	59	75	77
During flap retraction (1)	4	2	2	123	76	91	76
After flap retraction (1)	4	1	2	119	73	93	78
During incision (2)	5	2	2	121	74	90	83
After incision (2)	5	2	3	100	59	76	92
During flap retraction (2)	4	1	2	117	69	87	91
After flap retraction (2)	5	2	2	121	72	93	94
During nasal dissection (1)	3	1	2	109	64	80	110
After nasal dissection (1)	4	2	2	103	58	78	112
During nasal dissection (2)	4	1	1	89	47	63	118
After nasal dissection (2)	3	1	1	87	45	62	116
During maxil. osteotomy (1)	3	1	1	90	49	63	100
After maxil osteotomy (1)	5	2	2	95	52	67	95
During maxil. osteotomy (2)	3	1	1	111	65	79	96
After maxil osteotomy (2)	5	1	1	113	66	87	94
During lat nasal osteotomy (1)	4	1	2	116	68	83	94
After lat. nasal osteotomy (1)	5	1	2	126	77	93	92
During lat. nasal osteotomy (2)	3	1	1	118	71	86	99
After lat. nasal osteotomy (2)	4	1	1	123	73	92	97
During septal osteotomy	4	1	1	125	75	92	96
After septal osteotomy	5	1	2	113	66	89	96

Table 21 Patient 17

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	1	1	1	95	46	61	77
After incision (1)	2	3	2	96	48	63	76
During flap retraction (1)	3	3	2	107	58	75	78
After flap retraction (1)	4	3	3	110	58	76	78
During incision (2)	1	2	1	110	59	77	80
After incision (2)	3	3	2	111	57	78	79
During flap retraction (2)	3	3	2	118	61	80	80
After flap retraction (2)	4	3	2	114	59	80	80
During nasal dissection (1)	4	4	3	116	59	80	79
After nasal dissection (1)	4	3	3	115	58	77	77
During nasal dissection (2)	4	4	3	120	60	82	77
After nasal dissection (2)	4	4	3	118	58	81	78
During maxil. osteotomy (1)	4	4	3	120	58	80	72
After maxil. osteotomy (1)	4	3	3	121	59	81	70
During maxil. osteotomy (2)	4	4	3	120	58	81	74
After maxil osteotomy (2)	4	4	3	120	58	81	73
During lat. nasal osteotomy (1)	4	4	3	128	61	83	71
After lat. nasal osteotomy (1)	4	4	3	121	57	78	71
During lat. nasal osteotomy (2)	4	4	3	127	63	87	72
After lat. nasal osteotomy (2)	4	4	3	127	63	87	71
During septal osteotomy	4	4	3	130	63	90	75
After septal osteotomy	4	4	3	114	54	79	78

Table 22 Patient 20

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	2	2	2	104	53	64	41
After incision (1)	3	3	2	105	56	72	42
During flap retraction (1)	2	2	2	114	62	79	41
After flap retraction (1)	2	2	2	130	75	93	42
During incision (2)	4	3	3	126	73	92	43
After incision (2)	4	4	3	127	71	90	43
During flap retraction (2)	3	3	3	120	68	85	43
After flap retraction (2)	2	2	2	128	74	92	46
During nasal dissection (1)	1	2	1	123	70	88	46
After nasal dissection (1)	2	2	1	124	69	88	45
During nasal dissection (2)	3	3	3	115	63	80	46
After nasal dissection (2)	3	2	2	115	63	80	45
During maxil osteotomy (1)	2	1	1	126	71	89	46
After maxil osteotomy (1)	2	2	2	129	68	88	47
During maxil. osteotomy (2)	3	3	2	140	80	100	48
After maxil. osteotomy (2)	3	2	2	139	82	101	48
During lat nasal osteotomy (1)	3	2	1	123	68	86	47
After lat. nasal osteotomy (1)	3	2	1	114	63	80	45
During lat nasal osteotomy (2)	2	1	1	120	66	84	44
After lat. nasal osteotomy (2)	3	2	1	124	68	87	47
During septal osteotomy	2	2	1	130	75	93	45
After septal osteotomy	2	1	1	130	75	93	45

Table 23 Patient 23

Time	Evaluator I	Evaluator II		Blood Pressure			Pulse
		A	B	Syst	Dias	Mean	
During incision (1)	1	1	2	97	54	68	57
After incision (1)	3	2	2	97	54	68	56
During flap retraction (1)	2	1	2	110	67	81	67
After flap retraction (1)	2	1	1	110	67	81	65
During incision (2)	3	1	2	105	58	74	60
After incision (2)	3	2	2	106	63	77	65
During flap retraction (2)	3	1	2	107	64	78	62
After flap retraction (2)	3	1	2	115	71	86	68
During nasal dissection (1)	2	1	1	113	67	82	61
After nasal dissection (1)	3	1	2	113	67	82	64
During nasal dissection (2)	2	1	1	108	63	78	61
After nasal dissection (2)	2	1	2	119	64	79	62
During maxil. osteotomy (1)	2	1	1	106	60	75	58
After maxil. osteotomy (1)	2	1	1	105	60	75	59
During maxil. osteotomy (2)	2	1	2	121	73	89	64
After maxil. osteotomy (2)	3	1	2	123	74	90	65
During lat. nasal osteotomy (1)	2	1	1	115	69	84	63
After lat. nasal osteotomy (1)	3	1	2	118	70	86	63
During lat. nasal osteotomy (2)	2	1	1	114	68	83	62
After lat. nasal osteotomy (2)	2	1	2	123	74	90	62
During septal osteotomy	3	1	1	116	68	84	56
After septal osteotomy	3	2	2	122	75	91	55