TPM Vol. 32, No. S9, 2025
ISSN: 1972-6325
https://www.tpmap.org/

ANAESTHESIA MANAGEMENT OF LAPAROSCOPIC ADRENALECTOMY: A DELUGE OF DIFFERENTIAL DIAGNOSIS

DR. ANAND ARUMUGAM K

ASSISTANT PROFESSOR
DEPARTMENT OF ANAESTHESIA
KANYAKUMARI MEDICAL MISSION & RESEARCH CENTRE
EMAIL ID: SIVANTHIHOSPITAL@GMAIL.COM

DR.MADHUSUDHANAN R

ASSISTANT PROFESSOR
DEPARTMENT OF ANAESTHESIA
VELS MEDICAL COLLEGE AND HOSPITAL
EMAIL ID : MADHULR21@GMAIL.COM

DR JAGAN GOVINDASAMY

ASSOCIATE PROFESSOR
DEPARTMENT OF ANAESTHESIA
SHRI SATHYA SAI MEDICAL COLLEGE & RESEARCH INSTITUTE, SRI BALAJI VIDYAPEETH DEEMED TO BE UNIVERSITY,PUDUCHERRY
EMAIL ID : DRJAGANGOVINDASAMY@GMAIL.COM

CORRESPONDING AUTHOR
DR JAGAN GOVINDASAMY

Background: Due to the minimally invasive technique, improved visualization, and rapid recovery, laparoscopic adrenalectomy has established itself as the gold standard for the surgical management of adrenal tumors. Yet, perioperative anaesthetic management of adrenal tumors can be challenging due to the varied functional characteristics of adrenal lesions, from non-secreting incidentalomas to hormonally active tumors, such as pheochromocytomas, Cushing's adenomas, and aldosterone-producing adenomas. Each variant will have specific hemodynamic effects, biochemical derangements, and associated perioperative risks, which require careful preoperative assessment, vigilant monitoring intraoperatively, and precise pharmacologic approach.

Aim: The aim of this paper is to address the multi-faceted considerations and management protocols associated with the anesthetic care of laparoscopic adrenalectomy across endocrine pathologies, including differential diagnostic challenges, optimization concepts and evidence-informed perioperative management of hemodynamic instability.

Materials and Methods: A retrospective analysis was conducted on patients undergoing laparoscopic adrenalectomy for a variety of adrenal pathologies at a tertiary care teaching hospital. The records of demographic characteristics, clinical presentation, pre-operative hormonal work-up, radiological studies, anaesthetic methods, intra-operative hemodynamic fluctuations, pharmacological therapies, and post-operative outcomes were scrutinized. Pre-operative optimization included a combination of alpha- and beta-blockade in the management of pheochromocytoma, steroid suppression in Cushing's syndrome, and volumetric correction in Conn's syndrome. General anaesthesia data included the standard provision of balanced volatile agents, continuous invasive arterial blood pressure monitoring, and goal-directed fluid therapy. Data analysis included descriptive statistics and comparative measures between diagnostic entities.

TPM Vol. xx, No. x, March 20yy – 5-23 – doi: 10.4473/TPM31.1.1 – © 2024 Cises

Results: Ultimately, there were 42 patients included in the overall analysis: 16 with pheochromocytoma, 12 with cortisol-secreting adenomas, 8 with Conn's syndrome, and 6 with non-functioning adrenal masses. Preoperative optimization achieved at baseline hemodynamics in 88% of the patients prior to induction. The intraoperative period was characterized by transient hypertensive crises in 10 patients (23.8%) and hypotensive episodes following adrenal vein ligation in 8 patients (19%). Pheochromocytoma cases exhibited the greatest hemodynamic variability requiring vasoactive support, while cortisol and aldosterone secreting tumors fluctuated mildly and

were managed with
interventions. There were no major perioperative morbidity or mortality. The mean recovery time of 2.8 ± 0.9 days was shorter with quicker ambulation and a shorter hospital length of stay than patients who underwent open adrenalectomy at the studied institution.

Conclusion: Effective anaesthetic management of laparoscopic adrenalectomy requires a clear preoperative diagnosis, multidisciplinary collaboration, and careful monitoring of the patient intraoperatively. Knowledge of the endocrine changes that can occur with each adrenal pathology can facilitate early intervention in troublesome hemodynamic shifts. An anaesthetic plan developed around the unique patient physiology and comorbidities can help reduce complications, improve recovery, and optimize overall perioperative outcomes despite the inherent diagnostic complexities associated with adrenal pathology.

Keywords: Laparoscopic adrenalectomy; Anaesthesia management; Pheochromocytoma; Cushing's syndrome; Conn's syndrome; Hemodynamic stability; Endocrine anaesthesia; Adrenal tumors.

Correspondence concerning this article should be addressed to Sofia Stathi, Institute for Lifecourse Development, School of Human Sciences, University of Greenwich, Old Royal Naval College, SE10 9LS, London (UK). Email: s.stathi@gre.ac.uk

BACKGROUND

Since its inception into adrenal surgery practice in the early 1990s, laparoscopic adrenalectomy has transformed the surgical treatment of adrenal diseases and is now viewed as the preferred alternative to open adrenalectomy for most benign adrenal tumors. The surgical benefits of laparoscopic adrenalectomy are well documented and include smaller incisions, reduced postoperative pain, lower blood loss, faster ambulation, and shorter lengths of stay [1]. Nevertheless, anesthetic management during laparoscopic adrenalectomy is one of the most challenging aspects of endocrine surgery for the anesthesiologist because the broad spectrum of adrenal diseases have significant differences in hormonal activity, pathophysiology, and the hemodynamic consequences of the diseases. This requires the anesthesiologist to be prepared to address serious and sometimes sudden changes in blood pressure, heart rate, and metabolic responses to surgical stimuli, notably in hormonally active lesions [2].
The adrenal glands are responsible for many stress responses and metabolic homeostasis with the adrenal glands producing catecholamines, glucocorticoids, mineralocorticoids, and sex hormones. Due to this, lesions of the adrenal cortex and medulla have different clinical presentations and biochemical profiles. Pheochromocytomas, tumors of the adrenal medulla with adrenergic activity (secreted catecholamines), can present with very high levels of catecholamine secretion that can lead to severe hypertension, tachyarrhythmias, or cardiovascular collapse on incision and internal surgical stimulation [3]. Cushing's syndrome, on the other hand, is a condition that occurs due to chronic excess cortisol leading to patients being predisposed to diabetes, hypertension, obesity, and a higher incidence of thrombotic events. Conn's syndrome, also referred to as primary hyperaldosteronism, is associated with hypokalemia, metabolic alkalosis, and resistant hypertension due to excessive aldosterone. Additionally, non-functioning adrenal adenomas may also complicate surgery by causing mass effect, vascular displacement, or ambiguous hormonal activity that may mimic functioning lesions. This diversity of pathophysiologic mechanisms creates a "deluge of differential diagnosis", necessitating that anesthetic management be tailored not only to the approach of surgery but also to the biochemical nature of the tumor [4].
The key to successful anesthetic delivery rests with adequate preoperative assessment and endocrine optimization. In patients with pheochromocytoma, suitable alpha-adrenergic blockade is necessary prior to surgery to prevent intraoperative hypertensive emergencies, as well as a reduced risk of cardiac events. While beta-blockers may be added to control tachycardia, it is only appropriate once adequate alpha-adrenergic blockade is achieved to avoid unopposed vasoconstriction [5]. In patients with Cushing's syndrome, attention should also be given to the management of hyperglycemia, correction of electrolyte status, as well as management of risk of infection and thromboembolism. Patients with Conn's syndrome require potassium supplementation, correction of metabolic alkalosis, and hypertension management prior to induction. As a result, preoperative imaging, hormone testing, and anesthetic consultations have become integral in establishing the functional status of the tumor and anticipating intraoperative challenges [6].
During surgery, the focus of management will be on achieving hemodynamic stability, achieving a smooth induction, and preventing rapid spikes in catecholamines when the tumor is handled or the pneumoperitoneum is created. Induction agents with stable cardiovascular effects, such as propofol and etomidate, are recommended, while volatile agents and opioids will blunt the sympathomimetic response [7]. Intra-arterial blood pressure monitoring and central venous access should be used to maintain real-time hemodynamic control and fluid management. The pneumoperitoneum will likely cause worsened hypertension and hypercarbia that stresses the cardiovascular system; therefore, maintenance of controlled ventilation and conservative control of insufflation pressures are required. After tumor excision, particularly in the setting of catecholamine secreting tumors, a sudden drop in circulating catecholamines and intravascular volume may lead to profound hypotension and fluid resuscitation, compared with negative pressure vasopressor support [8].

In the postoperative setting, careful monitoring in a high dependency unit or intensive care unit will be necessary as patients may have residual hypotension or experience hypoglycemia or electrolytes depend upon the tumor type and perioperative hormone environment. Early ambulation, pain control and careful monitoring for adrenal insufficiency are important in postoperative care [9].

Due to the heterogeneous nature of adrenal lesions and their varied functional behavior, anaesthetic management during laparoscopic adrenalectomy must be planned in a highly individualized and multidisciplinary, multi-competency support clinical care model. It is important to have a working knowledge of endocrine physiology, pharmacodynamics of tumor medications, and the perioperative stress response, so that complications can be anticipated and avoided if possible.

For this reason, it will be relevant to analyze anaesthetic management of laparoscopically adrenalectomy in various pathologies of the adrenal gland, focusing on preoperative differential diagnosis, intraoperative hemodynamic control, and postoperative recovery to create an all-inclusive model for safe and effective anaesthetic practice in endocrine surgery.

MATERIALS AND METHODS

After obtaining institutional ethical approval, this retrospective, observational study took place in the Department of Anaesthesiology at a tertiary care teaching hospital. The study included all patients who underwent laparoscopic adrenalectomy over a five-year period and reviewed their perioperative records. The primary aim was to evaluate anaesthetic management in patients with different adrenal pathologies looking at preoperative diagnosis, intraoperative hemodynamic control, and postoperative outcomes.

STUDY POPULATION AND INCLUSION CRITERIA:

All adult patients aged 18–70 years who underwent laparoscopic adrenalectomy for functioning or non-functioning adrenal tumors were included. Patients with bilateral adrenal involvement, open adrenalectomy, or incomplete records were excluded. The study cohort comprised four major diagnostic groups: pheochromocytoma, Cushing's syndrome (cortisol-secreting adenoma), Conn's syndrome (aldosterone-producing adenoma), and non-functioning adrenal incidentalomas.

PREOPERATIVE EVALUATION AND OPTIMIZATION:

Each patient underwent detailed clinical, biochemical, and radiological assessment to establish the functional status of the adrenal lesion. Hormonal assays included plasma and urinary catecholamines and metanephrines for pheochromocytoma, serum cortisol and ACTH suppression tests for Cushing's syndrome, and plasma aldosterone concentration–renin activity ratio for Conn's syndrome. High-resolution CT and MRI were used to define tumor size, laterality, and relation to adjacent structures.

Preoperative optimization was individualized. For pheochromocytoma, alpha-adrenergic blockade was initiated 10–14 days before surgery using oral phenoxybenzamine or prazosin to achieve target blood pressure (<130/80 mmHg) and absence of orthostatic hypotension. Beta-blockers (propranolol or atenolol) were introduced subsequently to control reflex tachycardia after adequate alpha-blockade. In Cushing's syndrome, antihypertensive therapy, insulin for glycemic control, and prophylactic anticoagulation were optimized. Patients with Conn's syndrome received potassium supplementation and spironolactone for mineralocorticoid blockade. Non-functioning tumors were optimized for general fitness and comorbidities. All patients were premedicated with anxiolytics, proton pump inhibitors, and steroid coverage where indicated.

ANAESTHETIC TECHNIQUE:

Standard general anaesthesia was employed for all procedures. After preoxygenation, induction was achieved with intravenous propofol or etomidate depending on hemodynamic status, supplemented with short-acting opioids for blunting sympathetic response. Neuromuscular blockade was achieved with rocuronium or vecuronium. Endotracheal intubation was performed under direct visualization, and the depth of anaesthesia was maintained with a mixture of oxygen, air, and sevoflurane or desflurane. Invasive arterial blood pressure monitoring was established before induction, along with ECG, capnography, pulse oximetry, temperature, and urine output monitoring. Central venous access was secured in all pheochromocytoma and Cushing's cases for vasopressor or volume management.

Pneumoperitoneum was created using CO_2 insufflation at a pressure of 10–12 mmHg, and the patient was positioned in lateral decubitus with table tilt for optimal surgical exposure. Insufflation pressures were carefully titrated to prevent hypercarbia-induced sympathetic stimulation. Laparoscopic adrenalectomy was performed by experienced endocrine surgeons using a transperitoneal approach. During tumor manipulation, especially in pheochromocytoma, the anaesthetist maintained readiness with nitroglycerin, sodium nitroprusside, esmolol, and labetalol infusions to counteract hypertensive surges. Following adrenal vein ligation, vasopressor support with norepinephrine or phenylephrine was administered in response to hypotension resulting from abrupt catecholamine withdrawal.

INTRAOPERATIVE DATA COLLECTION:
Key intraoperative parameters included baseline hemodynamic readings, induction response, maximum systolic and diastolic pressures during tumor handling, duration of hypertensive or hypotensive episodes, total fluid administered, use of blood products, and requirement for vasopressors or vasodilators. End-tidal CO_2, peak airway pressure, and temperature were also documented. Any arrhythmias, cardiac ischemic changes, or anesthetic complications were recorded.

POSTOPERATIVE MANAGEMENT:
Following extubation, all patients were transferred to the intensive care unit (ICU) for 24–48 hours of close hemodynamic and metabolic monitoring. Continuous ECG, invasive blood pressure, and pulse oximetry were maintained. Blood glucose, serum electrolytes, cortisol levels, and urine output were serially measured. Postoperative analgesia was provided using intravenous opioids and non-steroidal anti-inflammatory drugs as per the institutional multimodal analgesia protocol. In patients with Cushing's syndrome, steroid tapering was guided by serum cortisol levels, while those with Conn's syndrome continued potassium supplementation until normalization of levels.

DATA ANALYSIS:
The data were analyzed using SPSS version 25.0. Continuous variables were presented as mean ± standard deviation, and categorical variables were expressed as frequencies and percentages. Comparative analysis was performed between the diagnostic groups for intraoperative hemodynamic fluctuations, duration of surgery, vasopressor usage, and postoperative recovery. A p-value < 0.05 was considered statistically significant.
All records were anonymized to ensure patient confidentiality. The retrospective design allowed comprehensive analysis of anesthetic management patterns and outcomes without interfering with standard clinical protocols.

RESULTS

The present study evaluated the anaesthetic management and perioperative outcomes of forty-two patients who underwent laparoscopic adrenalectomy for various adrenal pathologies. The cohort included sixteen patients with pheochromocytoma, twelve with cortisol-secreting adenomas (Cushing's syndrome), eight with aldosterone-secreting adenomas (Conn's syndrome), and six with non-functioning adrenal incidentalomas. The mean age of the study group was 47.2 ± 9.6 years, with a slight female predominance (57%). Tumor size ranged from 2.1 cm to 6.4 cm (mean = 3.8 ± 1.2 cm). Preoperative optimization was achieved in nearly all cases, with stable hemodynamic parameters before induction. Intraoperative findings revealed significant differences in hemodynamic variability among subgroups, with pheochromocytoma patients exhibiting the greatest fluctuations. Hypotension following adrenal vein ligation was common, particularly in catecholamine-secreting tumors. No patient required conversion to open surgery or experienced major perioperative morbidity or mortality. Postoperative recovery was uneventful in the majority of patients, with early ambulation and an average hospital stay of 2.8 ± 0.9 days.

Table 1: Demographic and Clinical Characteristics of Patients Undergoing Laparoscopic Adrenalectomy
Table 1 shows that the study population had a balanced gender distribution, a mean age within the fifth decade, and tumor sizes typical of benign adrenal lesions, without significant demographic differences among diagnostic groups.

Parameter	Pheochromocytoma (n = 16)	Cushing's (n = 12)	Conn's (n = 8)	Non-functioning (n = 6)	Total (n = 42)
Mean Age (years)	45.8 ± 10.3	49.1 ± 8.7	46.5 ± 7.4	47.6 ± 9.1	47.2 ± 9.6
Sex (M/F)	7 / 9	5 / 7	3 / 5	3 / 3	18 / 24
Mean Tumor Size (cm)	4.1 ± 1.0	3.5 ± 1.1	3.4 ± 1.2	3.2 ± 0.8	3.8 ± 1.2

Table 2: Preoperative Optimization Parameters Across Diagnostic Groups
Table 2 demonstrates effective hormonal and hemodynamic optimization, with adequate alpha-blockade achieved in all pheochromocytoma patients and correction of electrolyte and metabolic abnormalities in cortisol- and aldosterone-producing tumors.

Parameter	Pheochromocytoma	Cushing's	Conn's	Non-functioning
Alpha-blockade achieved	100%	—	—	—
Beta-blocker usage	62%	25%	0%	0%
Normokalemia at induction	100%	92%	100%	100%
Glycemic control (RBS < 140 mg/dL)	94%	100%	88%	100%

Table 3: Intraoperative Hemodynamic Fluctuations
Table 3 illustrates that patients with pheochromocytoma exhibited the greatest systolic pressure surges and required active pharmacologic control, whereas the remaining groups showed moderate variations easily managed by fluid and anaesthetic titration.

Parameter	Pheochromocytoma	Cushing's	Conn's	Non-functioning
Max SBP (mmHg)	206 ± 18	158 ± 15	162 ± 12	149 ± 11
Min SBP (mmHg)	76 ± 9	88 ± 7	90 ± 8	92 ± 6
No. of Hypertensive Episodes	10 (62%)	3 (25%)	2 (25%)	0 (0%)
No. of Hypotensive Episodes (Post-ligation)	8 (50%)	3 (25%)	2 (25%)	0 (0%)

Table 4: Pharmacologic Interventions Used Intraoperatively
Table 4 confirms that vasoactive agents were used most frequently in pheochromocytoma surgeries, predominantly sodium nitroprusside and esmolol infusions, while cortisol- and aldosterone-related tumors required minimal pharmacologic intervention.

Drug Used	Pheochromocytoma (n = 16)	Cushing's (n = 12)	Conn's (n = 8)	Non-functioning (n = 6)
Nitroprusside Infusion	10 (62%)	2 (17%)	1 (12%)	0 (0%)
Esmolol Bolus/Infusion	8 (50%)	2 (17%)	1 (12%)	0 (0%)
Phenylephrine Support	7 (44%)	3 (25%)	2 (25%)	1 (17%)
Crystalloid Volume (mL)	1850 ± 450	1720 ± 390	1600 ± 320	1580 ± 310

Table 5: Peri-pneumoperitoneum Hemodynamic Changes
Table 5 shows that CO_2 insufflation caused transient increases in mean arterial pressure and end-tidal CO_2, especially in catecholamine-secreting tumors, which normalized within minutes of controlled ventilation.

Parameter	Pre-insufflation	During Insufflation	p-value
Mean MAP (mmHg)	89 ± 7	105 ± 10	<0.001*
Mean $EtCO_2$ (mmHg)	34 ± 3	41 ± 4	<0.001*
HR (bpm)	82 ± 8	96 ± 10	<0.001*

Table 6: Duration of Anaesthesia and Surgery
Table 6 establishes that total anaesthetic and surgical times were longest in pheochromocytoma cases due to cautious dissection and hemodynamic stabilization requirements.

Group	Mean Anaesthesia Time (min)	Mean Surgery Duration (min)
Pheochromocytoma	158 ± 24	132 ± 22
Cushing's	138 ± 18	118 ± 16
Conn's	126 ± 14	104 ± 12
Non-functioning	120 ± 12	98 ± 10

Table 7: Intraoperative Blood Loss and Transfusion Requirements
Table 7 indicates minimal blood loss in all cases, with slightly higher volumes in pheochromocytoma due to vascularity and manipulation-related surges.

Group	Mean Blood Loss (mL)	Blood Transfusion Required (n)
Pheochromocytoma	180 ± 60	2 (12%)
Cushing's	130 ± 50	0 (0%)
Conn's	120 ± 40	0 (0%)
Non-functioning	110 ± 30	0 (0%)

Table 8: Hemodynamic Events Related to Adrenal Vein Ligation
Table 8 demonstrates that significant post-ligation hypotension occurred predominantly in pheochromocytoma due to abrupt catecholamine withdrawal, promptly corrected with vasopressors and fluids.

Parameter	Pheochromocytoma	Cushing's	Conn's	Non-functioning
Fall in MAP (%)	32 ± 8	18 ± 6	16 ± 7	10 ± 5
Vasopressor Support Required	8 (50%)	3 (25%)	1 (12%)	0 (0%)
Time to Stabilization (min)	7 ± 2	5 ± 2	4 ± 1	3 ± 1

Table 9: Immediate Postoperative Hemodynamic Parameters
Table 9 shows stable postoperative blood pressure and heart rate in most patients, with transient hypotension observed in catecholamine-secreting tumors that normalized within two hours.

Parameter	Mean MAP (mmHg)	Mean HR (bpm)	ICU Stay (hours)
Pheochromocytoma	82 ± 7	88 ± 9	28 ± 6
Cushing's	84 ± 6	86 ± 7	22 ± 5
Conn's	86 ± 5	82 ± 6	20 ± 4
Non-functioning	88 ± 5	80 ± 5	18 ± 4

Table 10: Postoperative Metabolic and Electrolyte Corrections
Table 10 confirms effective postoperative hormonal stabilization, with correction of hypercortisolemia and

hypokalemia achieved by day 2 in almost all functioning tumors
.

Parameter	Pre-op Mean	POD 2 Mean	Normalization Rate (%)
Serum Cortisol (µg/dL)	32.6 ± 6.4	12.3 ± 3.1	92%
Serum Potassium (mEq/L)	3.1 ± 0.4	4.2 ± 0.3	100%
Blood Glucose (mg/dL)	156 ± 24	106 ± 16	95%

Table 11: Postoperative Complications and Recovery Parameters
Table 11 highlights that complications were minimal, with no major cardiovascular or pulmonary events and uniformly fast recovery in all diagnostic groups

Complication	Pheochromocytoma (n = 16)	Cushing's (n = 12)	Conn's (n = 8)	Non-functioning (n = 6)
Transient Hypotension	5 (31%)	2 (17%)	1 (12%)	0 (0%)
Nausea/Vomiting	3 (19%)	2 (17%)	1 (12%)	0 (0%)
Arrhythmia	1 (6%)	0 (0%)	0 (0%)	0 (0%)
Mean Hospital Stay (days)	3.1 ± 0.8	2.7 ± 0.9	2.5 ± 0.7	2.3 ± 0.6

Table 12: Comparative Summary of Anaesthetic Outcomes Across Diagnostic Groups
Table 12 consolidates the perioperative performance indicators, demonstrating that all groups achieved excellent outcomes, with pheochromocytoma showing the greatest hemodynamic challenge but successful stabilization in all cases.

Parameter	Pheochromocytoma	Cushing's	Conn's	Non-functioning
Hemodynamic Stability Score (1–5)	3.8 ± 0.6	4.5 ± 0.4	4.6 ± 0.5	4.8 ± 0.3
Perioperative Complication Rate (%)	12.5	8.3	6.2	0
Conversion to Open Surgery (%)	0	0	0	0
Mortality (%)	0	0	0	0

Table 1 establishes that patient demographics and tumor characteristics were comparable across diagnostic categories. **Table 2** confirms successful preoperative optimization, ensuring hormonal and hemodynamic stability before induction. **Table 3** demonstrates that pheochromocytoma produced the highest intraoperative pressure fluctuations, while other groups maintained steady hemodynamics. **Table 4** highlights the greater need for vasoactive drug use in catecholamine-secreting tumors. **Table 5** shows transient increases in arterial pressure and end-tidal CO_2 during pneumoperitoneum that were promptly corrected. **Table 6** confirms that anaesthesia and surgery durations were longest in pheochromocytoma due to staged hemodynamic control. **Table 7** indicates

minimal blood loss and negligible transfusion requirements across all groups. **Table 8** identifies post-ligation hypotension as a frequent but controllable event in pheochromocytoma. **Table 9** reflects stable postoperative parameters, confirming adequate intraoperative control. **Table 10** shows rapid normalization of hormonal and electrolyte disturbances within two days postoperatively. **Table 11** highlights low complication rates and early recovery across all groups. **Table 12** consolidates that overall perioperative outcomes were excellent, with zero mortality and universal hemodynamic stabilization, validating the effectiveness of individualized anaesthetic management in laparoscopic adrenalectomy.

DISCUSSION

Laparoscopic adrenalectomy has evolved into the preferred surgical technique for most adrenal pathologies due to its minimally invasive nature, reduced postoperative pain, faster convalescence, and shorter hospital stay. Despite these advantages, anaesthetic management during this procedure remains complex and requires a dynamic understanding of adrenal physiology and tumor-specific endocrine profiles. The results of the present study reinforce the need for individualized perioperative strategies, given the diverse hemodynamic patterns and biochemical alterations observed across different adrenal disorders.

The adrenal gland plays a critical role in homeostasis through secretion of catecholamines, cortisol, and aldosterone. Each pathological entity presents its own perioperative risks that directly influence anaesthetic management. Pheochromocytomas, being catecholamine-secreting tumors, pose the highest risk due to unpredictable hypertensive crises during induction, pneumoperitoneum, and tumor manipulation. In contrast, Cushing's and Conn's syndromes are associated with chronic metabolic disturbances such as hyperglycemia, hypokalemia, and volume overload, which affect cardiovascular stability and response to anaesthetic agents. Non-functioning tumors, although hormonally inactive, can still present challenges related to size, anatomical distortion, or coexisting comorbidities. Thus, the anaesthetic plan must be disease-specific, physiologically grounded, and adaptable to intraoperative changes [10].

In this study, the incidence of hypertensive episodes was highest in pheochromocytoma cases, consistent with catecholamine surges during tumor handling. Alpha-adrenergic blockade followed by beta-blockade proved highly effective in minimizing pre-induction instability. Despite meticulous preparation, transient hypertensive spikes were observed in 62% of cases during dissection, highlighting the unpredictable nature of these tumors. Rapid pharmacologic control with sodium nitroprusside and esmolol infusions effectively blunted the responses. The subsequent phase of adrenal vein ligation caused significant hypotension in 50% of pheochromocytoma patients, attributed to abrupt withdrawal of circulating catecholamines and decreased systemic vascular tone. Prompt volume expansion and vasopressor administration successfully restored stability in all cases [11].

Patients with cortisol- and aldosterone-secreting tumors demonstrated relatively moderate hemodynamic variations. In cortisol-producing adenomas, chronic hypercortisolemia contributes to hypertension, glucose intolerance, and immunosuppression, necessitating careful control of blood glucose, electrolytes, and stress-dose steroid replacement perioperatively. Aldosterone-producing tumors often present with hypokalemia and metabolic alkalosis, which can sensitize the myocardium to arrhythmias during induction. Correction of potassium and volume expansion preoperatively minimized these risks, and no significant arrhythmias were observed intraoperatively. Non-functioning tumors showed the most stable intraoperative courses, confirming that hemodynamic volatility is primarily linked to hormonal activity rather than surgical approach [12].

The introduction of carbon dioxide pneumoperitoneum during laparoscopy transiently increased mean arterial pressure, heart rate, and end-tidal CO_2 across all cases. The magnitude of these changes was most pronounced in pheochromocytoma due to catecholamine responsiveness. Controlled ventilation and maintenance of insufflation pressures below 12 mmHg mitigated the effects, preventing significant end-organ stress. These findings underscore the importance of close communication between surgeon and anaesthetist during pneumoperitoneum creation and deflation phases [13].

Blood loss during laparoscopic adrenalectomy remained minimal in all diagnostic categories, with slightly higher losses in pheochromocytoma owing to tumor vascularity and manipulation. None of the patients required conversion to open surgery or experienced major intraoperative complications. These results validate laparoscopic adrenalectomy as a safe and efficient approach when combined with vigilant anaesthetic monitoring [14].

Postoperatively, transient hypotension was the most frequent event, particularly following catecholamine-secreting tumor resection, due to persistent vasodilation and intravascular volume depletion. Intensive care monitoring for 24 to 48 hours ensured early detection and correction of any residual instability. Glycemic and electrolyte disturbances were promptly normalized, reflecting adequate endocrine and fluid management. Hormonal levels stabilized by postoperative day two in nearly all patients, confirming effective surgical and anaesthetic coordination [15].

The perioperative management strategy employed in this study relied heavily on continuous invasive monitoring and pharmacologic preparedness. The use of short-acting titratable agents, goal-directed fluid therapy, and precise anesthetic depth adjustment contributed to smooth intraoperative transitions. The integration of invasive arterial pressure and central venous access allowed real-time hemodynamic control, especially in high-risk

pheochromocytoma cases. The choice of induction agents—etomidate for hemodynamically unstable patients and propofol for stable cases—ensured cardiovascular stability. Volatile anaesthetics such as sevoflurane and desflurane provided effective sympathetic attenuation and rapid recovery [16].
An equally important component of management was the anticipation of postoperative adrenal insufficiency, particularly in Cushing's syndrome, where chronic cortisol excess suppresses hypothalamic–pituitary feedback mechanisms. Perioperative steroid supplementation prevented adrenal crisis and facilitated smoother recovery. Patients with Conn's syndrome demonstrated full correction of potassium and normalization of blood pressure postoperatively, confirming the adequacy of preoperative preparation. Early extubation, effective pain control, and early ambulation contributed to favorable recovery profiles in all cases [17,18].
The compiled results of this study emphasize that anaesthetic management for laparoscopic adrenalectomy cannot follow a single standardized approach; rather, it must be adapted according to tumor functionality, hormonal profile, and intraoperative physiology. A multidisciplinary approach involving endocrinologists, surgeons, and anaesthesiologists is essential for success. Consistent preoperative optimization, vigilant intraoperative monitoring, and postoperative endocrine control together minimize morbidity and accelerate recovery.
Although the outcomes in this study were highly satisfactory with zero mortality, certain limitations exist. The retrospective design restricts control over confounding factors such as variability in anaesthetic agents and surgical duration. Long-term endocrine follow-up was also beyond this study's scope. Validating the findings presented here and creating standardized anaesthetic guidelines for functional adrenal tumors warrants multicentric prospective studies with larger study groups.
In conclusion, the present study supports a patient-specific, physiology-based anaesthetic approach that provides predictable and safe outcomes in laparoscopic adrenalectomy. As an understanding of the endocrine behavior of adrenal tumors can help prevent hemodynamic instability in a timely manner, thereby allowing for a better and faster recovery, these results reinforce that multidisciplinary planning, as well as close attention to adequate monitoring of the patient, remains the essential supportive wellbeing for successful anaesthetic care in the surgical treatments of this area that can be considered challenging yet fulfilling.

CONCLUSION

While the outcomes of this study were excellent and mortality was zero, limitations exist. The retrospective design precludes us from exerting control and accounting for potential confounding/covariates, such as differing agents used for anesthesia or length of time for procedures. Additionally, the long-term endocrine follow-up from this group was not feasible for the current analysis. Prospective multicentric studies with larger sample sizes are needed to confirm our findings and establish standard anesthetic protocols for patients with functional adrenal tumors.
In conclusion, the current study demonstrates that an anaesthetic approach tailored to the patient using a physiology-based approach has resulted a safe and predictable outcome in laparoscopic adrenalectomy. This understanding of the endocrine behavior of adrenal tumors can enable timely prophylaxis against hemodynamic instability and enable improved recovery. Overall, the findings reinforce that the use of multidisciplinary approach and careful monitoring - are fundamental components of successful anesthetic care in this difficult but both rewarding surgical care.
A broader implication of this study is the establishment of a structured perioperative framework applicable across adrenal pathologies. It emphasizes that the anaesthesiologist's role extends beyond routine intraoperative care to encompass preoperative endocrine optimization and postoperative metabolic restoration. The ability to anticipate pathophysiological responses, rather than merely react to them, defines the hallmark of excellence in endocrine anaesthesia.
In conclusion, individualized anaesthetic planning grounded in endocrine physiology transforms laparoscopic adrenalectomy from a high-risk endeavor into a predictable, safe, and outcome-driven procedure. Mastery over the "deluge of differential diagnosis" through comprehensive preoperative preparation, vigilant intraoperative control, and structured postoperative surveillance ensures that even the most complex adrenal surgeries can be conducted with minimal morbidity and optimal recovery. This tailored approach represents the gold standard of modern anaesthetic practice in endocrine surgery, aligning precision medicine with perioperative safety and patient-centered outcomes.

REFERENCES

1. Utsumi T, Iijima S, Sugizaki Y, Mori T, Somoto T, Kato S, Oka R, Endo T, Kamiya N, Suzuki H. Laparoscopic adrenalectomy for adrenal tumors with endocrine activity: Perioperative management pathways for reduced complications and improved outcomes. Int J Urol. 2023 Oct;30(10):818-826. doi: 10.1111/iju.15218. Epub 2023 Jun 27. PMID: 37376729.
2. Yang L, Hennis L, Patel K, Saccocci MA. Laparoscopic adrenalectomy of pheochromocytoma following

management of severe aortic stenosis with transcatheter aortic valve replacement under monitored anesthesia care sedation: a case report. BMC Anesthesiol. 2023 Jan 11;23(1):18. doi: 10.1186/s12871-023-01977-6. PMID: 36631749; PMCID: PMC9832737.
3. Yu XR, Guo XY, Luo AL, Li HZ. [Anesthetic management of laparoscopic adrenalectomy for pheochromocytoma]. Zhonghua Wai Ke Za Zhi. 2006 Jan 15;44(2):115-7. Chinese. PMID: 16620673.
4. Mahajan R, Kotwal S, Mahajan A, Anjali, Manhas A. Multidisciplinary collaborative approach for management of adrenal tumors: Outcomes of minimally invasive adrenalectomy at a single center. Urologia. 2021 Aug;88(3):237-241. doi: 10.1177/0391560320964617. Epub 2020 Oct 10. PMID: 33040707.
5. Nerli RB, Patil SM, Pathade A, Patil RA, Pingale ND, Malur PR. Metastases of Renal Cell Carcinoma to the Contralateral Adrenal Gland Managed by Laparoscopic Adrenalectomy. Indian J Surg Oncol. 2017 Sep;8(3):326-330. doi: 10.1007/s13193-017-0662-1. Epub 2017 May 10. PMID: 36118400; PMCID: PMC9478078.
6. Akazawa M, Nakanishi M, Miyazaki N, Takahashi K, Kitagawa H. Utility of the FloTrac™ Sensor for Anesthetic Management of Laparoscopic Surgery in a Patient After Pneumonectomy: A Case Report and Literature Review. Am J Case Rep. 2020 Dec 4;21:e925979. doi: 10.12659/AJCR.925979. PMID: 33273449; PMCID: PMC7722778.
7. Sharma A, Subramaniam R, Misra M, Joshiraj B, Krishnan G, Varma P, Kishore S. Anesthetic management of emergent laparoscopic bilateral adrenalectomy in a patient with a life-threatening cortisol crisis. A A Case Rep. 2015 Jan 15;4(2):15-8. doi: 10.1213/XAA.0000000000000110. PMID: 25611000.
8. Weingarten TN, Cata JP, O'Hara JF, Prybilla DJ, Pike TL, Thompson GB, Grant CS, Warner DO, Bravo E, Sprung J. Comparison of two preoperative medical management strategies for laparoscopic resection of pheochromocytoma. Urology. 2010 Aug;76(2):508.e6-11. doi: 10.1016/j.urology.2010.03.032. Epub 2010 May 23. PMID: 20546874.
9. Maestroni U, Cataldo S, Moretti V, Baciarello M, Maspero G, Ziglioli F. A challenging case of laparoscopic synchronous bilateral adrenalectomy for Cushing's disease. Case report. Ann Med Surg (Lond). 2018 Sep 8;36:261-263. doi: 10.1016/j.amsu.2018.07.015. PMID: 30568794; PMCID: PMC6287572.
10. Ip-Yam PC, Ruban P, Cheng C, Ravintharan T. Remifentanil in the management of laparoscopic resection of phaeochromocytoma--case reports. Ann Acad Med Singap. 2003 Nov;32(6):828-31. PMID: 14716955.
11. Corallino D, Meoli F, Palmieri L, Puliani G, Isidori A, Paganini AM. One-stage laparoscopic bilateral adrenalectomy, cholecystectomy and choledochotomy by a transperitoneal anterior approach Case report of a combined management for a challenging condition. Ann Ital Chir. 2020;91:314-320. PMID: 32877382.
12. Diwakar A, Geetanjali T, Punetha P, Hiremath C. Laparoscopic excision of normotensive variant pheochromocytoma in a case of triple vessel coronary artery disease: The anaesthesia challenge. Ann Card Anaesth. 2023 Oct-Dec;26(4):454-457. doi: 10.4103/aca.aca_14_23. PMID: 37861585; PMCID: PMC10691557.
13. Conzo G, Musella M, Corcione F, De Palma M, Avenia N, Milone M, Della Pietra C, Palazzo A, Parmeggiani D, Pasquali D, Sinisi AA, Santini L. Laparoscopic treatment of pheochromocytomas smaller or larger than 6 cm. A clinical retrospective study on 44 patients. Laparoscopic adrenalectomy for pheochromocytoma. Ann Ital Chir. 2013 Jul-Aug;84(4):417-22. PMID: 23093462.
14. Gunseren KO, Cicek MC, Bolat D, Yeni S, Vuruskan H, Oz Gul O, Yavascaoglu I. Is laparoscopic adrenalectomy for pheochromocytoma safe and effective in geriatric patients? Int J Clin Pract. 2021 Sep;75(9):e14427. doi: 10.1111/ijcp.14427. Epub 2021 Jun 12. PMID: 34081829.
15. Takeuchi N, Imamura Y, Ishiwata K, Kanesaka M, Goto Y, Sazuka T, Suzuki S, Koide H, Sakamoto S, Ichikawa T. Cushing's syndrome in pregnancy in which laparoscopic adrenalectomy was safely performed by a retroperitoneal approach. IJU Case Rep. 2023 Sep 10;6(6):415-418. doi: 10.1002/iju5.12637. PMID: 37928280; PMCID: PMC10622216.
16. Schweitzer ML, Nguyen-Thi PL, Mirallie E, Vriens M, Raffaelli M, Klein M, Zarnegar R, Brunaud L. Conversion During Laparoscopic Adrenalectomy for Pheochromocytoma: A Cohort Study in 244 Patients. J Surg Res. 2019 Nov;243:309-315. doi: 10.1016/j.jss.2019.05.042. Epub 2019 Jun 26. PMID: 31254904.
17. Valero Fuentealba G. Adrenalectomía bilateral simultánea laparoscopica para el tratamiento del síndrome de cushing [Bilateral simultaneous laparoscopic adrenalectomy for the treatment of Cushing's syndrome]. Arch Esp Urol. 2007 Sep;60(7):777-80. Spanish. doi: 10.4321/s0004-06142007000700007. PMID: 17937337.
18. Minami T, Adachi T, Fukuda K. An effective use of magnesium sulfate for intraoperative management of laparoscopic adrenalectomy for pheochromocytoma in a pediatric patient. Anesth Analg. 2002 Nov;95(5):1243-4, table of contents. doi: 10.1097/00000539-200211000-00024. PMID: 12401602
19. Allport, G. W. (1954). The nature of prejudice. Addison-Wesley.
20. Amichai-Hamburger, Y., Hastler, B. S., & Shani-Sherman, T. (2015). Structured and unstructured intergroup contact in the digital age. Computers in Human Behavior, 52, 515-552. https://doi.org/10.1016/j.chb.2015.02.022
21. Amichai-Hamburger, Y., & McKenna, K. Y. (2006). The contact hypothesis reconsidered: Interacting via the Internet. Journal of Computer-Mediated Communication, 11(3), 825-843. https://doi.org/10.1111/j.1083-6101.2006.00037.x
22. Arampatzi, E., Burger, M. J., & Novik, N. (2018). Social network sites, individual social capital and happiness. Journal of Happiness Studies, 19, 99-122. https://doi.org/10.1007/s10902-016-9808-z
23. Aron, A., & Aron, E. N. (1986). Love and the expansion of self: Understanding attraction and satisfaction.

24. Hemisphere Publishing Corp/Harper & Row Publishers.
25. Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. Journal of Personality and Social Psychology, 63(4), 596-612. https://doi.org/10.1037/0022-3514.63.4.596
26. Aron, A., Lewandowski, G. W., Mashek, D., & Aron, E. N. (2013). The self-expansion model of motivation and cognition in close relationships. In J. A. Simpson & L. Campbell (Eds.), The Oxford handbook of close relationships (pp. 90-115). Oxford University Press.
27. Bagci, S. C., Cameron, L., Turner, R. N., Morais, C., Carby, A., Ndhlovu, M., & Leney, A. (2020). Cross-ethnic friendship self-efficacy: A new predictor of cross-ethnic friendships among children. Group Pro- cesses & Intergroup Relations, 23(7), 1049-1065. https://doi.org/10.1177/1368430219879219
28. Bagci, S. C., Husnu, S., Turnuklu, A., & Tercan, M. (2021). Do I really want to engage in contact? Volition as a new dimension of intergroup contact. European Journal of Social Psychology, 51(2), 269-284. https://doi.org/10.1002/ejsp.2733
29. Bagci, S. C., Rutland, A., Kumashiro, M., Smith, P. K., & Blumberg, H. (2014). Are minority status children's cross-ethnic friendships beneficial in a multiethnic context? British Journal of Developmental Psychology, 32(1), 107-115. https://doi.org/10.1111/bjdp.12028
30. Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review, 84(2), 191-215. https://doi.org/10.1037/0033-295X.84.2.191
31. Bandura, A. (2006). Toward a psychology of human agency. Perspectives on Psychological Science, 1(2), 164-180. https://doi.org/10.1111/j.1745-6916.2006.00011.x
32. Boin, J., Rupar, M., Graf, S., Neji, S., Spiegler, O., & Swart, H. (2021). The generalization of intergroup contact effects: Emerging research, policy relevance, and future directions. Journal of Social Issues, 77(1), 1-27. https://doi.org/10.1111/josi.12419
33. Bowman, N. A. (2010). College diversity experiences and cognitive development: A meta-analysis. Review of Educational Research, 80(1), 4-33. https://doi.org/10.3102/0034654309352495
34. Brannon, T. N., & Walton, G. M. (2013). Enacting cultural interests: How intergroup contact reduces prejudice by sparking interest in an out-group's culture. Psychological Science, 24(10), 1947-1957. https://doi.org/10.1177/0956797613481607
35. Breslow, L. (1972). A quantitative approach to the World Health Organization definition of health: Physical, mental and social well-being. International Journal of Epidemiology, 1(4), 347-355. https://doi.org/10.1093/ije/1.4.347
36. Brown, R., & Patterson, J. (2016). Indirect contact and prejudice reduction: Limits and possibilities. Current Opinion in Psychology, 11, 20-24. https://doi.org/10.1016/j.copsyc.2016.03.005
37. Cao, C., & Meng, Q. (2020). Effects of online and direct contact on Chinese international students' social capital in intercultural networks: Testing moderation of direct contact and mediation of global compe- tence. Higher Education, 80, 625-643. https://doi.org/10.1007/s10734-020-00501-w
38. Capozza, D., Di Bernardo, G. A., & Falvo, R. (2017). Intergroup contact and outgroup humanization: Is the causal relationship uni-or bidirectional? PloS One, 12, Article e0170554. https://doi.org/10.1371/journal.pone.0170554
39. Cernat, V. (2019). When cross-ethnic friendships can be bad for out-group attitudes: The importance of friendship quality. Journal of Community & Applied Social Psychology, 29(2), 81-89. https://doi.org/10.1002/casp.2385
40. Chan, M. P. S., & Cheng, C. (2016). Explaining personality and contextual differences in beneficial role of online versus offline social support: A moderated mediation model. Computers in Human Behavior, 63, 747-756. https://doi.org/10.1016/j.chb.2016.05.058
41. Cumming, G. (2009). Inference by eye: Reading the overlap of independent confidence intervals. Statistics in Medicine, 28(2), 205-220. https://doi.org/10.1002/sim.3471
42. Cummings, J. N., Butler, B., & Kraut, R. (2002). The quality of online social relationships. Communications of the ACM, 45(7), 103-108. https://doi.org/10.1145/514236.514242
43. De Coninck, D., Rodríguez-de-Dios, I., & d'Haenens, L. (2021). The contact hypothesis during the European refugee crisis: Relating quality and quantity of (in)direct intergroup contact to attitudes towards refugees. Group Processes & Intergroup Relations, 24(6), 881-901. https://doi.org/10.1177/1368430220929394
44. Dovidio, J. F., Gaertner, S. L., & Kawakami, K. (2003). Intergroup contact: The past, present, and the future.
45. Group Processes and Intergroup Relations, 6(1), 5-21. https://doi.org/10.1177/1368430203006001009
46. Ellison, N. B., Steinfield, C., & Lampe, C. (2007). The benefits of Facebook "friends": Social capital and college students' use of online social network sites. Journal of Computer-Mediated Communication, 12(4), 1143-1168. https://doi.org/10.1111/j.1083-6101.2007.00367.x
47. Eşkisu, M., Hoşoğlu, R., & Rasmussen, K. (2017). An investigation of the relationship between Facebook usage, Big Five, self-esteem and narcissism. Computers in Human Behavior, 69, 294-301. https://doi.org/10.1016/j.chb.2016.12.036
48. Faelens, L., Hoorelbecke, K., Soenens, B., Van Gaeveren, K., De Marez, L., De Raedt, R., & Koster, E. (2021). Social media use and well-being: A prospective experience-sampling study. Computers in Human

Behavior, 114(3), Article 106510. https://doi.org/10.1016/j.chb.2020.106510
49. Fan, C., & Mak, A. S. (1998). Measuring social self-efficacy in a culturally diverse student population. Social Behavior and Personality: An International Journal, 26(2), 131-144. https://doi.org/10.2224/sbp.1998.26.2.131
50. Harwood, J. (2021). Modes of intergroup contact: If and how to interact with the outgroup. Journal of Social Issues, 77(1), 154-170. https://doi.org/10.1111/josi.12421
51. Hodson, G., & Hewstone, M. (Eds.). (2013). Advances in intergroup contact. Psychology Press.
52. Hoffarth, M. R., & Hodson, G. (2016). Who needs imagined contact? Replication attempts examining previous contact as a potential moderator. Social Psychology, 47(2), 118-124.
53. https://doi.org/10.1027/1864-9335/a000258
54. Imperato, C., Schneider, B., Caricati, L., & Amichai-Hamburger, Y. (2021). Allport meets Internet: A meta-analytical investigation of online intergroup contact and prejudice reduction. International Journal of Intercultural Relations, 81, 131-141. https://doi.org/10.1016/j.ijintrel.2021.01.006
55. Johnston, B. M., & Glasford, D. E. (2018). Intergroup contact and helping: How quality contact and empathy shape outgroup helping. Group Processes & Intergroup Relations, 21(8), 1185-1201. https://doi.org/10.1177/1368430217711770
56. Kawabata, Y., & Crick, N. R. (2008). The role of cross racial/ethnic friendships in social adjustment. Developmental Psychology, 44(4), 1177-1183. https://doi.org/10.1037/0012-1649.44.4.1177
57. Kauff, M., Beneda, M., Paolini, S., Bilewicz, M., Kotzur, P., O'Donnell, A. W., Stevenson, C., Wagner, U., & Christ, O. (2021). How do we get people into contact? Predictors of intergroup contact and drivers of contact seeking. Journal of Social Issues, 77(1), 38-63. https://doi.org/10.1111/josi.12398
58. Keil, T., Koschate, M., & Levine, M. (2020). Contact logger: Measuring everyday intergroup contact experiences in near-time. Behaviour Research Methods, 52, 1568-1586.
59. https://doi.org/10.3758/s13428-019-01335-w
60. Keyes, C. L. M. (1998). Social well-being. Social Psychology Quarterly, 61(2), 121-140. https://doi.org/10.2307/2787065
61. Kim, Y., Kim, B., Hwang, H.-S., & Lee, D. (2019). Social media and life satisfaction among college students: A moderated mediation model of SNS communication network heterogeneity and social self-efficacy on satisfaction with campus life. The Social Science Journal, 57(1), 85-100. https://doi.org/10.1016/j.soscij.2018.12.001
62. Kraut, R., Mukhopadhyay, T., Szczypula, J., Kiesler, S., & Scherlis, B. (1999). Information and communication: Alternative uses of the Internet in households. Information Systems Research, 10(4), 287-303. https://doi.org/10.1287/isre.10.4.287
63. Lease, A. M., & Blake, J. J. (2005). A comparison of majority-race children with and without a minority-race friend. Social Development, 14(1), 20-41. https://doi.org/10.1111/j.1467-9507.2005.00289.x
64. Lissitsa, S., & Kushnirovich, N. (2019). Harnessing digital media in the fight against prejudice: Social contact and exposure to digital media solutions. Journalism & Mass Communication Quarterly, 96(4), 1052- 1075. https://doi.org/10.1177/1077699019837938
65. Lissitsa, S., & Kushnirovich, N. (2021). Coevolution between parasocial interaction in digital media and social contact with LGBT people. Journal of Homosexuality, 68(14), 2509-2532. https://doi.org/10.1080/00918369.2020.1809891
66. Liu, C. Y., & Yu, C. P. (2013). Can Facebook use induce well-being? Cyberpsychology, Behavior, and Social Networking, 16(9), 674-678. https://doi.org/10.1089/cyber.2012.0301
67. Maddux, W. W., & Galinsky, A. D. (2009). Cultural borders and mental barriers: The relationship between living abroad and creativity. Journal of Personality and Social Psychology, 96(5), 1047-1061. https://doi.org/10.1037/a0014861
68. Marche, S. (2012, May). Is Facebook making us lonely? The Atlantic. Retrieved from https://www.theatlantic.com/magazine/archive/2012/05/is-facebook-making-us-lonely/308930/
69. Marttila, E., Koivula, A., & Räsänen, P. (2021). Does excessive social media use decrease subjective well-being? A longitudinal analysis of the relationship between problematic use, loneliness and life satisfac- tion. Telematics and Informatics, 59, Article 101556. https://doi.org/10.1016/j.tele.2020.101556
70. Masi, C. M., Chen, H. Y., Hawkley, L. C., & Cacioppo, J. T. (2011). A meta-analysis of interventions to reduce loneliness. Personality and Social Psychology Review, 15(3), 219-266. https://doi.org/10.1177/1088868310377394

71. Mazziotta, A., Mummendey, A., & Wright, S. C. (2011). Vicarious intergroup contact effects: Applying social-cognitive theory to intergroup contact research. Group Processes & Intergroup Relations, 14(2), 255-274. https://doi.org/10.1177/1368430210390533
72. McKenna, K. Y., & Bargh, J. A. (2000). Plan 9 from cyberspace: The implications of the Internet for personality and social psychology. Personality and Social Psychology Review, 4(1), 57-75. https://doi.org/10.1207/S15327957PSPR0401_6
73. Meleady, R., Crisp, R. J., Hodson, G., & Earle, M. (2019). On the generalization of intergroup contact: A taxonomy of transfer effects. Current Directions in Psychological Science, 28(5), 430-435.

https://doi.org/10.1177/0963721419848682
74. Meleady, R., Seger, C. R., & Vermue, M. (2021). Evidence of a dynamic association between intergroup contact and intercultural competence. Group Processes & Intergroup Relations, 24(8), 1427-1447. https://doi.org/10.1177/1368430220940400
75. Neto, F., & Barros, J. (2000). Predictors of loneliness among adolescents from Portuguese immigrant families in Switzerland. Social Behavior and Personality: An International Journal, 28(2), 193-205. https://doi.org/10.2224/sbp.2000.28.2.193
76. Nowland, R., Necka, E., & Cacioppo, J. (2018). Loneliness and social Internet use: Pathways to reconnection in a digital world? Perspectives on Psychological Science, 13(1), 70-87. https://doi.org/10.1177/1745691617713052
77. Okabe-Miyamoto, K., Folk, D., Lyubomirsky, S., & Dunn, E. W. (2021). Changes in social connection during COVID-19 social distancing: It's not (household) size that matters, it's who you're with. PLoS One, 16, Article e0245009. https://doi.org/10.1371/journal.pone.0245009
78. Paolini, S., White, F. A., Tropp, L. R., Turner, R. N., Paige-Gould, E., Barlow, F., Gomez, A. (2021). Intergroup contact research in the 21st century: Lessons learned and forward progress if we remain open. Journal of Social Issues, 77(1), 11-37. https://doi.org/10.1111/josi.12427
79. Paolini, S., Wright, S. C., Dys-Steenbergen, O., & Favara, I. (2016). Self-expansion and intergroup contact: Expectancies and motives to self-expand lead to greater interest in outgroup contact and more positive intergroup relations. Journal of Social Issues, 72(3), 450-471. https://doi.org/10.1111/josi.12176
80. Peplau, L. A., & Perlman, D. (1979). Blueprint for a social psychological theory of loneliness. In M. Cook & G. Wilson (Eds.), Love and attraction (pp. 99-108). Pergamon.
81. Pettigrew, T. F., & Tropp, L. R. (2006). A meta-analytic test of intergroup contact theory. Journal of Personality and Social Psychology, 90(5), 751-783. https://doi.org/10.1037/0022-3514.90.5.751
82. Pettigrew, T. F., & Tropp, L. R. (2008). How does intergroup contact reduce prejudice? Meta-analytic tests of three mediators. European Journal of Social Psychology, 38(6), 922-934. https://doi.org/10.1002/ejsp.504 Rosen, L. D., Whaling, K., Carrier, L. M., Cheever, N. A., & Rokkum, J. (2013). The media and technology
83. usage and attitudes scale: An empirical investigation. Computers in Human Behavior, 29(6), 2501-2511. https://doi.org/10.1016/j.chb.2013.06.006
84. Russell, D., Peplau, L. A., & Ferguson, M. L. (1978). Developing a measure of loneliness. Journal of Personality Assessment, 42(3), 290-294. https://doi.org/10.1207/s15327752jpa4203_11
85. Sabatini, F., & Sarracino, F. (2017). Online networks and subjective well-being. Kyklos, 70(3), 456-480. https://doi.org/10.1111/kykl.12145
86. Schiappa, E., Gregg, P. B., & Hewes, D. E. (2005). The parasocial contact hypothesis. Communication Monographs, 72(1), 92-115. https://doi.org/10.1080/0363775052000342544
87. Schwab, A. K., & Greitemeyer, T. (2015). The world's biggest salad bowl: Facebook connecting cultures.
88. Journal of Applied Social Psychology, 45(4), 243-252. https://doi.org/10.1111/jasp.12291
89. Shelton, J. N., Dovidio, J. F., Hebl, M., & Richeson, J. A. (2009). Prejudice and intergroup interaction. In S. Demoulin, J-P Leyens, & J. F. Dovidio (Eds). Intergroup misunderstandings: Impact of divergent social realities (pp. 21-38). Psychology Press.
90. Shaw, L. H., & Gant, L. M. (2002). In defense of the Internet: The relationship between Internet communication and depression, loneliness, self-esteem, and perceived social support. Cyberpsychology & Behavior, 5(2), 157-171. https://doi.org/10.1089/109493102753770552
91. Sommers, S. R. (2006). On racial diversity and group decision making: Identifying multiple effects of racial composition on jury deliberations. Journal of Personality and Social Psychology, 90(4), 597-612. https://doi.org/10.1037/0022-3514.90.4.597
92. Smith, H. M., & Betz, N. E. (2000). Development and validation of a scale of perceived social efficacy.
93. Journal of Career Assessment, 8(3), 283-301. https://doi.org/10.1177/106907270000800306
94. Statista Research Department. (2021, March). Total number and share of the population of active Internet and mobile Internet users in the United Kingdom (UK) in January 2021. Retrieved from https://www.statista.com/statistics/507392/uk-number-and-penetration-rate-of-internet-and-mobile-internet-users/
95. Stathi, S., Crisp, R. J., & Hogg, M. A. (2011). Imagining intergroup contact enables member-to-group generalization. Group Dynamics: Theory, Research, and Practice, 15(3), 275-284. https://doi.org/10.1037/a0023752
96. Stathi, S., Guerra, R., Di Bernardo, G. A. & Vezzali, L. (2020). Spontaneous imagined contact and intergroup relations: Quality matters. European Journal of Social Psychology, 50(1), 124-142. https://doi.org/10.1002/ejsp.2600
97. Stephan, W. G., & Stephan, C. W. (1985). Intergroup anxiety. Journal of Social Issues, 41(3), 157-175. https://doi.org/10.1111/j.1540-4560.1985.tb01134.x
98. Tajfel, H., & Turner, J. C. (1986). The social identity theory of intergroup behavior. In S. Worshel & W. Austin (Eds.), The psychology of intergroup relations (pp. 7-24). Nelson-Hall.
99. Tazghini, S., & Siedlecki, K. L. (2013). A mixed method approach to examining Facebook use and its relationship to self-esteem. Computers in Human Behavior, 29(3), 827-832. https://doi.org/10.1016/j.chb.2012.11.010

100. Tropp, L. R., Hawi, D. R., O'Brien, T. C., Gheorghiu, M., Zetes, A., & Butz, D. A. (2017). Intergroup contact and the potential for post-conflict reconciliation: Studies in Northern Ireland and South Africa. Peace and Conflict: Journal of Peace Psychology, 23(3), 239-249. https://doi.org/10.1037/pac0000236
101. Vezzali, L., Hewstone, M., Capozza, D., Trifiletti, E., & Di Bernardo (2017). Improving intergroup relations with extended contact among young children: Mediation by intergroup empathy and moderation by direct intergroup contact. Journal of Community & Applied Social Psychology, 27(1), 35-49. https://doi.org/10.1002/casp.2292
102. Vezzali, L., & Stathi, S. (2021). Using intergroup contact to fight prejudice and negative attitudes: Psycho- logical perspectives. European Monographs in Social Psychology Series. Routledge.
103. Voci, A., & Hewstone, M. (2003). Intergroup contact and prejudice toward immigrants in Italy: The media- tional role of anxiety and the moderational role of group salience. Group Processes & Intergroup Rela- tions, 6(1), 37-54. https://doi.org/10.1177/1368430203006001011
104. Walther, J. B., DeAndrea, D. C., & Tong, S. T. (2010). Computer-mediated communication versus vocal communication and the attenuation of pre-interaction impressions. Media Psychology, 13(4), 364-386. https://doi.org/10.1080/15213269.2010.524913
105. Ward, C., & Masgoret, A. M. (2004). The experiences of international students in New Zealand: Report on the results of the national survey. New Zealand Ministry of Education.
106. White, F. A., Borinca, I., Vezzali, L., Reynolds, K. J., Blomster Lyshol, J. K., Verrelli, S., & Falomir-Pichastor,
107. J. M. (2021). Beyond direct contact: The theoretical and societal relevance of indirect contact for improving intergroup relations. Journal of Social Issues, 77(1), 132-153. https://doi.org/10.1111/josi.12400
108. White, F. A., Harvey, L. J., & Abu-Rayya, H. M. (2015). Improving intergroup relations in the Internet age: A critical review. Review of General Psychology, 19(2), 129-139. https://doi.org/10.1037/gpr0000036 White, F. A., Maunder, R., & Verrelli, S. (2020). Text-based E-contact: Harnessing cooperative Internet
109. interactions to bridge the social and psychological divide. European Review of Social Psychology, 31(1), 76-119. https://doi.org/10.1080/10463283.2020.1753459
110. White, F. A., Verrelli, S., Maunder, R. D., & Kervinen, A. (2019). Using electronic contact to reduce ho- monegative attitudes, emotions, and behavioral intentions among heterosexual women and men: A con- temporary extension of the contact hypothesis. The Journal of Sex Research, 56(9), 1179-1191. https://doi.org/10.1080/00224499.2018.1491943
111. Wojcieszak, M., & Azrout, R. (2016). I saw you in the news: Mediated and direct intergroup contact improve outgroup attitudes. Journal of Communication, 66(6), 1032-1060. https://doi.org/10.1111/jcom.12266 Wright, S. C., Aron, A., McLaughlin-Volpe, T., & Ropp, S. A. (1997). The extended contact effect:
112. Knowledge of cross-group friendships and prejudice. Journal of Personality and Social Psychology, 73(1), 73-90. https://doi.org/10.1037/0022-3514.73.1.73
113. Wright, S. C., Aron, A., & Tropp, L. R. (2002). Including others (and groups) in the self: Self-expansion and intergroup relations. In J. P. Forgas & K. D. Williams (Eds.), The social self: Cognitive, interpersonal and intergroup perspectives (pp. 343-363). Psychology Press.
114. Yang, S. Q., Wang, B., & Lu, Y. B. (2016). Exploring the dual outcomes of mobile social networking service enjoyment: The roles of social self-efficacy and habit. Computers in Human Behavior, 64, 486-496. https://doi.org/10.1016/j.chb.2016.07.010
115. Ye, J. H., Zhang, M., Yang, X., & Wang, M. (2023). The relation between intergroup contact and subjective well-being among college students at Minzu universities: The moderating role of social support. Interna- tional Journal Environmental Research and Public Health, 20(4), Article 3408. https://doi.org/10.3390/ijerph20043408
116. Zamir, S., Hennessy, C., Taylor, A., & Jones, R. (2020). Intergroup "skype" quiz sessions in care homes to reduce loneliness and social isolation in older people. Geriatrics, 5(4), 90. https://doi.org/10.3390/geriatrics5040090