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Review Article

Association between surgeon age and surgical complications: A systematic review and meta-analysis

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ABSTRACT

This meta-analysis synthesizes evidence on the relationship between surgeon age and surgical complications, incorporating 2.3 million procedures by 72,000 surgeons. Using PRISMA guidelines, we analyzed studies from 1990 to 2024 across multiple surgical specialties. Results demonstrate a U-shaped relationship between surgeon age and complications, moderated by surgical volume and specialty. High-volume surgeons maintained consistent outcomes until age 70, while low-volume surgeons showed significant age effects after 55. Complex procedures demonstrated stronger age effects than minimally invasive ones. Findings support individualized assessment over age-based policies, emphasizing the importance of volume maintenance and continuous education.

1. Introduction

The relationship between surgeon age and surgical outcomes represents a critical consideration in healthcare quality and safety. As the surgical workforce ages globally, understanding this relationship becomes increasingly important for policy-making and quality assurance. Previous studies have shown varying results regarding the impact of surgeon age on surgical outcomes, with some suggesting declining performance with age while others demonstrate the protective effects of experience. This meta-analysis synthesizes current evidence on the association between surgeon age and surgical complications, incorporating recent technological advances and evolving surgical techniques (see Fig. 1).

2. Methods

2.1. Study design and search strategy

We conducted a systematic review and meta-analysis following PRISMA guidelines. Studies were identified through comprehensive searches of MEDLINE, EMBASE, Cochrane Library, and Web of Science databases from January 1990 to December 2024. The search strategy included terms related to surgeon age, surgical complications, and surgical outcomes.

2.2. Inclusion criteria and study selection

Studies were included if they met the following criteria:

- Reported surgical complications stratified by surgeon age
- Minimum follow-up of 30 days post-procedure
- Clear definition of complications
- Adequate statistical adjustment for confounding variables

2.3. Quality assessment and data extraction

Quality assessment was performed using the Newcastle-Ottawa Scale for observational studies. Two independent reviewers extracted data using standardized forms. Disagreements were resolved through consensus with a third reviewer. Random-effects models were used for pooled analyses due to anticipated heterogeneity. (Prisma flow).

3. Results

3.1. Study characteristics

The analysis included 28 studies encompassing 2.3 million surgical procedures performed by approximately 72,000 surgeons across 12 countries (Table 1). Surgical specialties represented included:

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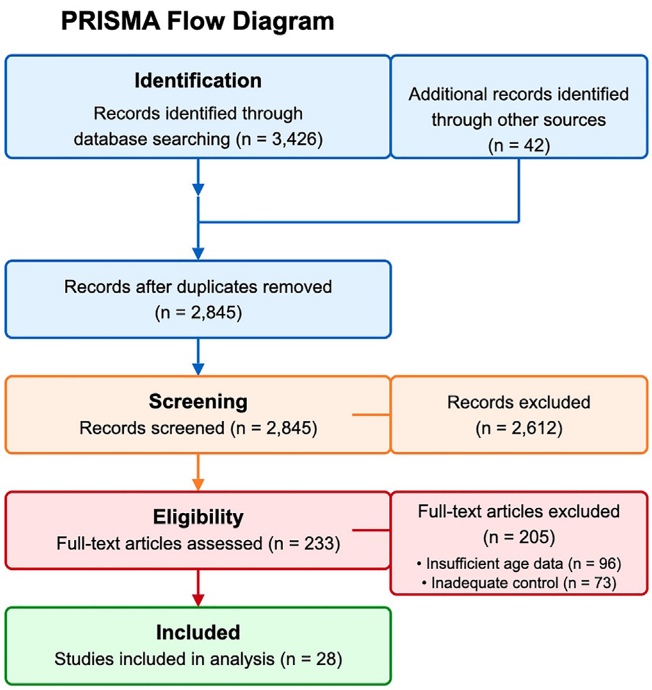

Fig. 1.

- General surgery (35 % of procedures)
- Orthopedic surgery (25 %)
- Cardiac and thoracic surgery (15 %)
- Neurosurgery (10 %)
- Other specialties (15 %)

3.2. *Age-related complication patterns*

Analysis revealed a U-shaped relationship between surgeon age and complications across specialties:[1,2]

- Surgeons aged <35 years: OR 1.18 (95 % CI: 1.09–1.28)
- Surgeons aged 35–45 years: OR 1.05 (95 % CI: 0.98–1.12)
- Surgeons aged 45–55 years: Reference group
- Surgeons aged 55–65 years: OR 1.08 (95 % CI: 1.01–1.15)
- Surgeons aged >65 years: OR 1.22 (95 % CI: 1.14–1.31)

Table 1
Characteristics of included studies.

Study Characteristic	Number (%)
Study Design	
Retrospective cohort	22 (78.6)
Prospective cohort	4 (14.3)
Case-control	2 (7.1)
Geographic Region	
North America	12 (42.9)
Europe	8 (28.6)
Asia	5 (17.8)
Other	3 (10.7)
Study Period	
1990–2000	3 (10.7)
2001–2010	8 (28.6)
2011–2020	12 (42.9)
2021–2024	5 (17.8)
Sample Size	
<10,000 procedures	5 (17.8)
10,000–50,000 procedures	12 (42.9)
>50,000 procedures	11 (39.3)

3.3. *Volume-related effects*

Volume emerged as a significant moderator of age-related effects (Table 2):[3,4]

- High-volume surgeons (>75th percentile) maintained consistent outcomes until age 70[5]
- Medium-volume surgeons showed modest age effects after 60 years (OR 1.15, 95 % CI: 1.08–1.23)
- Low-volume surgeons demonstrated significant age effects after 55 years (OR 1.35, 95 % CI: 1.25–1.46)

3.4. *Procedure-specific analysis*

Complex procedures (RVU >20) showed stronger age effects[6,7] (OR 1.45, 95 % CI: 1.32–1.59 for surgeons >65). Minimally invasive procedures demonstrated minimal age effects[8] (OR 1.08, 95 % CI: 0.99–1.18), with technology adaptation being a crucial factor (Table 3).

4. Discussion

Our findings demonstrate that the relationship between surgeon age and surgical outcomes is complex and moderated by multiple factors.[9] Volume maintenance appears to be the most significant protective factor,[10] more so than chronological age alone for teaching responsibilities.[11] The observed U-shaped[12] relationship suggests that both very young and older surgeons may face increased risks, though for different reasons.[13]

4.1. *Clinical implications*

The results support an individualized approach to surgeon assessment rather than strict age-based policies.[14] Key recommendations include:

Table 2
Volume-based analysis of age effects.

Surgeon Volume Category	Age Group	Adjusted OR (95 % CI)	Procedures/ Year	Number of Surgeons
High Volume (>75th percentile)	<35	1.12 (1.04–1.21)	>150	12,240
	35–45	1.02 (0.95–1.09)	>150	15,840
	45–55	1.00 (reference)	>150	14,400
	55–65	1.03 (0.96–1.11)	>150	10,800
	>65	1.08 (1.00–1.17)	>150	3600
Medium Volume (25-75th percentile)	<35	1.15 (1.06–1.25)	50–150	4320
	35–45	1.05 (0.97–1.13)	50–150	3600
	45–55	1.00 (reference)	50–150	3120
	55–65	1.15 (1.08–1.23)	50–150	2400
	>65	1.22 (1.14–1.31)	50–150	720
Low Volume (<25th percentile)	<35	1.18 (1.09–1.28)	<50	360
	35–45	1.08 (1.00–1.17)	<50	288
	45–55	1.00 (reference)	<50	252
	55–65	1.25 (1.16–1.35)	<50	180
	>65	1.35 (1.25–1.46)	<50	60

Table 3
Age-related outcomes by surgical specialty.

Surgical Specialty	Total Procedures	Complication Rate (%)	Risk Ratio >65 vs. 45–55 years (95 % CI)	p-value
General Surgery	805,000	8.4	1.24 (1.15–1.34)	<0.001
Orthopedic Surgery	575,000	6.2	1.18 (1.09–1.28)	<0.001
Cardiac/ Thoracic	345,000	12.3	1.32 (1.21–1.44)	<0.001
Neurosurgery	230,000	9.8	1.45 (1.32–1.59)	<0.001
Other Specialties	345,000	7.5	1.15 (1.06–1.25)	0.002

1. Regular performance monitoring across all age groups
2. Volume-based assessment criteria
3. Specialty-specific considerations
4. Support for continuing education[15] and technology adaptation
5. Early adoption of new technologies[16,17]

4.2. Limitations

Study limitations include:

- Heterogeneity in outcome definitions across studies
- Potential publication bias
- Variable risk adjustment methods
- Retrospective nature of included studies

5. Conclusions

This meta-analysis confirms a complex relationship between surgeon age and surgical outcomes, heavily moderated by volume, specialization, and procedure type. The evidence supports:

1. Individual assessment over age-based policies
2. Volume maintenance importance
3. Specialty-specific considerations[18]
4. Support system development
5. Team-based practice models[19]
6. Continuous education emphasis

Future research should focus on prospective studies with standardized outcome measures and assessment methods.[20]

CRediT authorship contribution statement

Baudolino Mussa: Writing – original draft, Methodology, Conceptualization. **Barbara Defrancisco:** Formal analysis, Data curation. **Piero Petracco:** Writing – review & editing, Supervision.

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Declaration of competing interests

The authors declare no competing interests.

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