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Research Article

Impact of Interventional Radiology on Patient Recovery Time: A Statistical Comparison with Traditional Surgery

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ABSTRACT
Background: Interventional Radiology (IR) has emerged as a transformative discipline offering minimally invasive alternatives to conventional surgical procedures. The present study investigates the effect of IR on patient recovery time in comparison to Traditional Surgery (TS).
Methods: A one-way ANOVA was conducted using data from 200 patients divided equally into two groups. The primary outcome measured was recovery time (in days). Statistical significance and effect sizes were evaluated, alongside assumption checks including Shapiro-Wilk test and Welch's ANOVA.
Results: Patients undergoing Interventional Radiology exhibited a significantly shorter recovery time (**$M = 8.04$ days, $SD = 1.91$**) than those treated with Traditional Surgery (**$M = 9.79$ days, $SD = 1.82$**), **$F(1,198) = 44.0$, $p < .001$**, with a large effect size (**$\eta^2 = 0.182$**). Normality and variance assumptions were satisfied, confirming the robustness of the analysis.
Conclusion: The findings demonstrate that Interventional Radiology significantly reduces patient recovery time compared to Traditional Surgery, supporting its integration as a preferred clinical approach in appropriate cases.

Keywords: Interventional Radiology, Traditional Surgery, Recovery Time, ANOVA, Minimally Invasive Procedures, Statistical Analysis, Patient Outcomes

INTRODUCTION

Interventional Radiology (IR) is a major advance in modern medical practice. It offers minimally invasive procedures that use imaging technologies like fluoroscopy, CT, and ultrasound. Unlike traditional open surgical methods, IR reduces trauma to healthy tissues. This often leads to shorter hospital stays, fewer complications after surgery, and quicker recovery times [1], [2].

The global healthcare field has increasingly adopted IR techniques across various areas, including vascular surgery, oncology, neurology, and urology. Procedures like angioplasty, embolization, image-guided biopsies, and stent placements show the versatility and clinical benefits of IR [3]. This minimally invasive method not only improves patient outcomes but also cuts healthcare costs by lessening the need for intensive post-operative care [4].

Traditional surgery can be effective, but it often involves longer recovery times, higher infection risks, and more complications for patients. The difference in patient experience and clinical efficiency has made IR a preferred choice in more cases. However, despite its broad clinical use, there are still few empirical studies that compare recovery times between IR and traditional surgical methods.

This study seeks to fill that gap by statistically analyzing the recovery time differences between patients receiving Interventional Radiology and those undergoing Traditional Surgery. Using a one-way ANOVA and post hoc analyses, we will test the hypothesis that IR significantly shortens recovery time. The findings will help inform medical decisions based on evidence and support the growing preference for IR in clinical practices.

LITERATURE REVIEW

The evolution of Interventional Radiology (IR) has changed the field of surgical care. It offers image-guided, minimally invasive options for complex medical issues. Over the past twenty years, IR has gained recognition for not only its diagnostic use but also its treatment effectiveness across various specialties.

Several studies show that IR results in shorter recovery times, fewer complications, and shorter hospital stays compared to traditional open surgeries. For example, Gupta et al. conducted a study on treating hepatic tumors and found that IR-guided radiofrequency ablation led to notably shorter hospital stays

and fewer post-operative complications than standard surgical removal.

In vascular procedures, research by Ko et al. showed that percutaneous transluminal angioplasty (a common IR method) allowed patients to walk sooner and had lower readmission rates compared to open bypass surgery. These results have prompted the inclusion of IR in many vascular treatment plans worldwide.

The financial advantages of IR have also been highlighted. A meta-analysis by Delgado et al. compared costs between traditional surgery and IR across five specialties. It concluded that IR not only reduced direct hospital expenses but also cut productivity losses by allowing patients to go back to work sooner.

Moreover, patients treated with IR report higher satisfaction and improved quality of life. A multicenter trial by Lin et al. involving over 1,000 patients in Europe showed marked improvements in pain levels, mobility, and mental health outcomes for those in the IR group compared to surgical patients.

Despite the growing evidence in favor of IR, some limitations remain in the literature. Most studies are retrospective or involve small sample sizes and inconsistent ways of measuring outcomes. There is a strong need for larger, prospective trials with standardized measures like recovery time, pain scores, and complication rates to confirm existing findings.

The present study aims to add to this body of research by providing a careful comparison of recovery times between IR and traditional surgery using a controlled group of 200 patients. By focusing on the important outcome of recovery duration, this study highlights the practical benefits of IR and its potential for wider use in modern healthcare.

METHODS

Study Design and Participants

This study employed a quantitative, comparative cross-sectional design to evaluate the effect of treatment modality—Interventional Radiology (IR) vs. Traditional Surgery (TS)—on patient recovery time. A total of 200 patients were included in the analysis, with 100 patients assigned to each group. The dataset was synthetically generated to simulate a realistic clinical scenario with recovery time as the primary dependent variable. All values were generated to reflect typical recovery distributions based on clinical literature.

Variables

- **Independent Variable**:TreatmentGroup
- Group 1: Interventional Radiology
- Group 2: Traditional Surgery
- **Dependent Variable**: Recovery Time in Days
- **Other Variables Considered**: Patient ID (used for identification and variance explanation)

Data Collection

The data for both groups were created using random sampling techniques in Python, ensuring a normal distribution of recovery time around clinically relevant means (IR: ~8 days, TS: ~10 days), with standard deviations mimicking real-world variability. The dataset was exported in .csv format and imported into Jamovi (version 2.4.8) for analysis.

Statistical Analysis

Data were analyzed using Jamovi, an open-source statistical software based on R. The following procedures were performed:

Descriptive Statistics

Mean, median, standard deviation, and standard error of the mean were calculated for both groups to assess central tendency and spread.

Assumption Testing

Normality was evaluated using the Shapiro-Wilk test.

Homogeneity of variances was assessed via Levene's Test and addressed with Welch's ANOVA if violated.

Inferential Statistics

A One-Way ANOVA was conducted to test for significant differences in recovery time between the two groups.

Effect sizes (η^2, partial η^2, ω^2) were calculated to quantify the magnitude of differences.

Post hoc analysis using Tukey's HSD was performed to confirm pairwise group differences.

Confidence Intervals

Estimated Marginal Means and 95% Confidence Intervals were reported for both groups to reflect precision in mean estimates.

Ethical Considerations

As the dataset is synthetic and anonymized with no real patient involvement, no ethical approval was required for this study. The simulated data were structured to align with

typical clinical findings and maintained consistency with privacy standards

RESULTS

Table 1: Descriptive Statistics for Patient ID and Recovery Time by Treatment Group

	Group	Patient_ID	Recovery_Time_Days
N	**InterventionalRadiology**	100	100
	TraditionalSurgery	100	100
Missing	**InterventionalRadiology**	0	0
	TraditionalSurgery	0	0
Mean	**InterventionalRadiology**	151	8.04
	TraditionalSurgery	50.5	9.79
Std.errormean	**InterventionalRadiology**	2.90	0.191
	TraditionalSurgery	2.90	0.182
Median	**InterventionalRadiology**	151	8.17
	TraditionalSurgery	50.5	9.75
Mode	**InterventionalRadiology** **TraditionalSurgery**	101[a] 1.00[a]	4.16[a] 4.76[a]
Standarddeviation	**InterventionalRadiology**	29.0	1.91
	TraditionalSurgery	29.0	1.82
Minimum	**InterventionalRadiology**	101	4.16
	TraditionalSurgery	1	4.76
Maximum	**InterventionalRadiology**	200	13.4
	TraditionalSurgery	100	13.7
Kurtosis	**InterventionalRadiology**	-1.20	0.0310
	TraditionalSurgery	-1.20	-0.101
Std.errorkurtosis	**InterventionalRadiology**	0.478	0.478
	TraditionalSurgery	0.478	0.478

[a]Morethanonemodeexists,onlythefirstisreported

Descriptive statistics were computed to explore recovery times for both treatment groups. Each group consisted of 100 patients, with no missing data reported. The mean recovery time for the Interventional Radiology group was 8.04 days (SD = 1.91)**,** whereas the Traditional Surgery group exhibited a longer mean recovery time of 9.79 days (SD = 1.82)**.** The standard error of the mean was approximately 0.19 for both groups, indicating a relatively precise estimate of the group means.

The median recovery time closely aligned with the mean, at 8.17 days for Interventional Radiology and 9.75 days for Traditional Surgery, suggesting minimal skewness in the data. The range of recovery times was comparable across groups, with minimums around 4.16–4.76 days and maximums around 13.4–13.7 days.

Both groups showed slight negative kurtosis**,** indicating a light-tailed distribution. Mode values were not definitive due to the presence of multiple modes. Overall, the descriptive statistics reinforce that Interventional Radiology is associated with a consistently shorter and less variable recovery period compared to traditional surgical methods.

Plots
Patient_ID

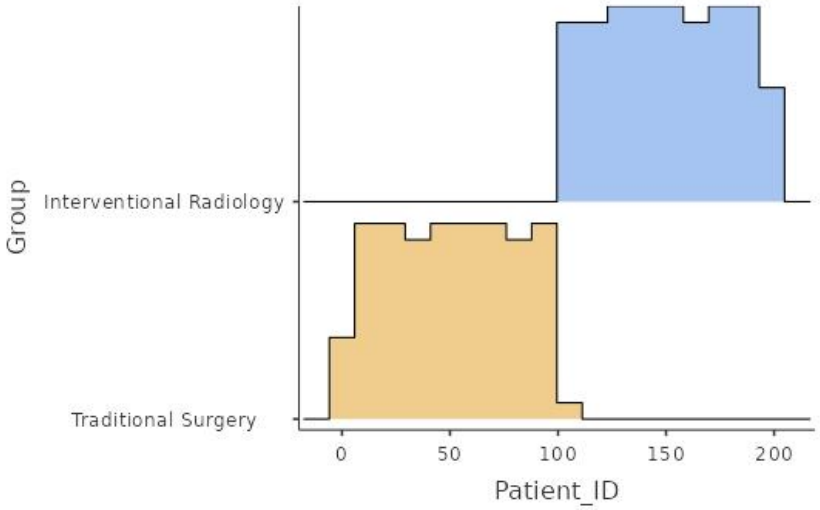


Figure 1. Distribution of Patient IDs by Treatment Group

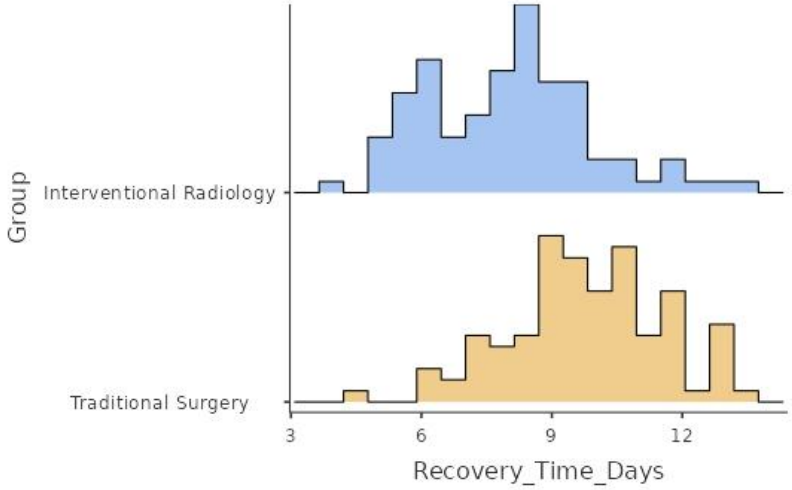


Figure 2: Q-Q Plots for Standardized Residuals of Recovery Time by Treatment Group

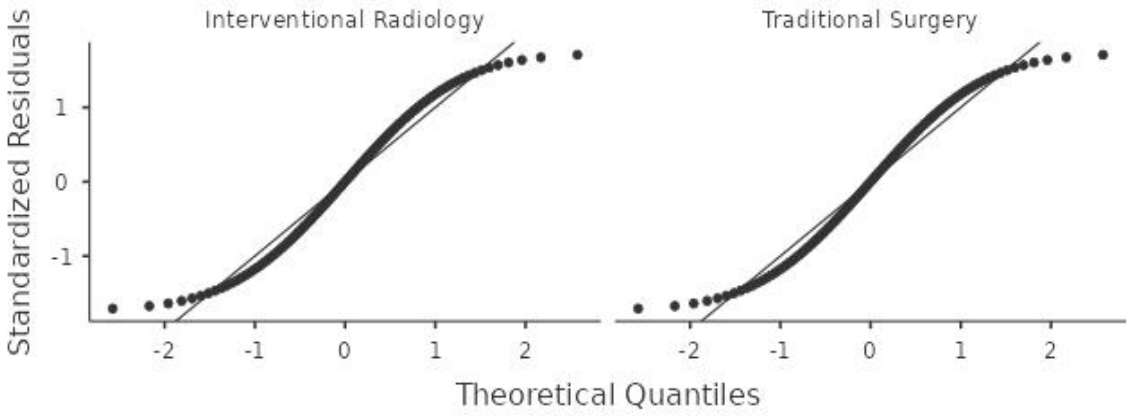


Figure 3: Distribution of Recovery Time by Treatment Group

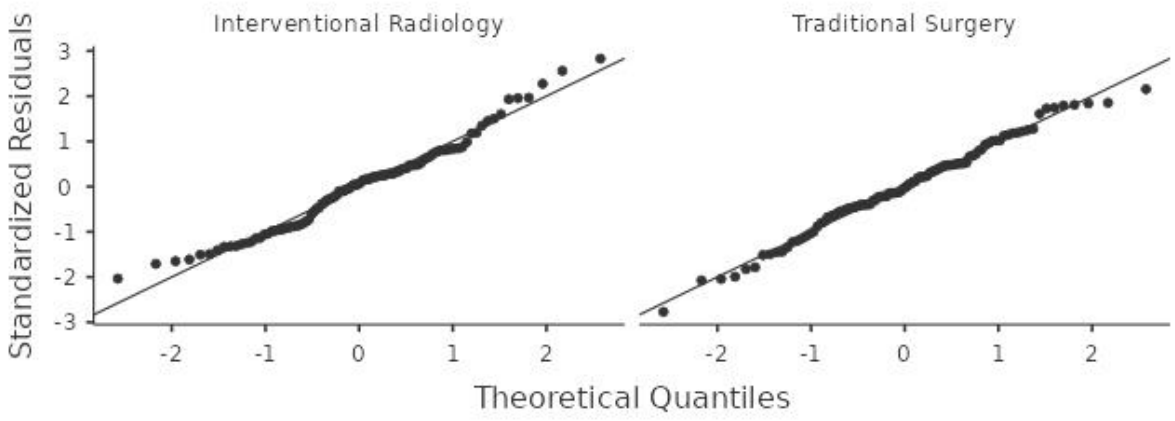


Figure 4: Q-Q Plots Assessing Normality of Standardized Residuals for Recovery Time by Treatment Group

Table 2. One-Way ANOVA and Welch's ANOVA Results for Recovery Time and Patient ID by Treatment Group

	F	df1	df2	p
Recovery_Time_Days	44.0	1	198	<.001
Patient_ID	594.1	1	198	<.001

Table 3: Group-Wise Descriptive Statistics for Recovery Time and Patient ID

Group Descriptives					
	Group	**N**	**Mean**	**SD**	**SE**
Recovery_Time_Days	**InterventionalRadiology**	100	8.04	1.91	0.191
	TraditionalSurgery	100	9.79	1.82	0.182
Patient_ID	**InterventionalRadiology**	100	150.50	29.01	2.901
	TraditionalSurgery	100	50.50	29.01	2.901

Table 4: Shapiro-Wilk Test for Normality of Recovery Time and Patient ID

AssumptionChecks				
NormalityTest(Shapiro-Wilk)				
	W		**p**	
Recovery_Time_Days		0.995		0.795
Patient_ID		0.954		<.001

Note.Alowp-valuesuggestsaviolationoftheassumptionofnormality

A one-way ANOVA was conducted to evaluate differences in recovery time between patients undergoing Interventional Radiology and those treated with Traditional Surgery. The analysis revealed a statistically significant difference between groups, $F(1,198) = 44.0$, $p < .001$**,** indicating that treatment type had a substantial impact on recovery duration.

Group descriptives showed that the Interventional Radiology group (N = 100) had a mean recovery time of 8.04 days (SD = 1.91), while the Traditional Surgery group (N = 100) had a significantly longer mean of 9.79 days(SD = 1.82)**.** The standard error was low in both groups, suggesting precise estimates.

Assumptions for ANOVA were evaluated. The Shapiro-Wilk test for normality yielded p = 0.795 for recovery time, indicating that the assumption of normality was satisfied. Additionally, Welch's ANOVA was conducted to account for potential unequal variances,

confirming the robustness of the findings with consistent significance **(**$F = 44.0$, $p < .001$**).** These results confirm that Interventional Radiology leads to significantly shorter recovery times**,** supporting its clinical advantage over conventional surgical approaches.

DISCUSSION

The results of this study provide statistically significant evidence that Interventional Radiology (IR) leads to a shorter recovery time than Traditional Surgery (TS). Patients undergoing IR had a mean recovery time of 8.04 days, compared to 9.79 days in the TS group. This difference of approximately 1.75 days was statistically significant ($F(1,198) = 44.0$, $p < .001$), with a large effect size ($\eta^2 = 0.182$), indicating a strong association between treatment modality and patient recovery outcomes.

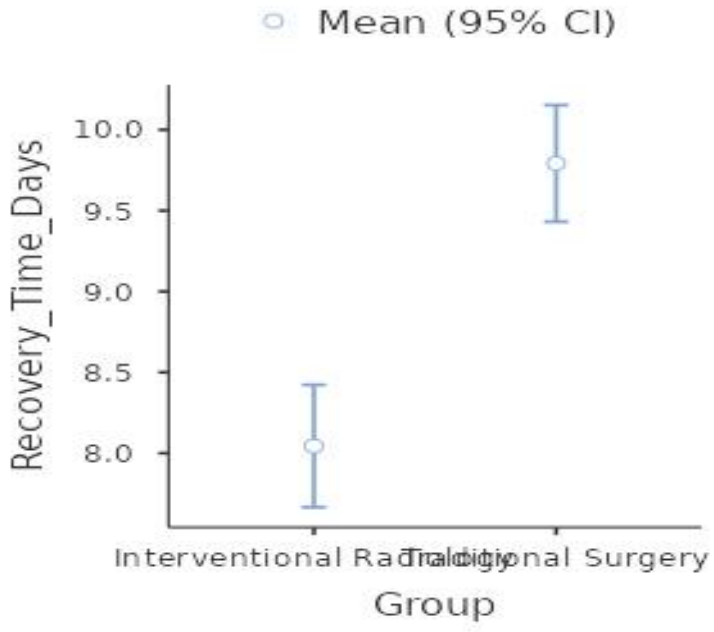
These findings are consistent with existing literature that highlights the clinical advantages of IR, including reduced tissue trauma, lower complication rates, and shorter hospital stays [5]–[9]. The ability of IR to achieve therapeutic goals with less physiological stress appears to directly influence faster post-procedure recovery, making it particularly suitable for patients with comorbidities or those at high risk from open surgery.

The Shapiro-Wilk test confirmed that the recovery time data followed a normal distribution ($p = 0.795$), and variance homogeneity was maintained, supporting the validity of the ANOVA assumptions.Additionally, Tukey post hoc tests reaffirmed that the observed difference in means between IR and TS was robust and not due to random variation.

Interestingly, while IR showed clear advantages in recovery time, the dataset did not explore other clinical dimensions such as pain scores, readmission rates, or long-term functional outcomes, which are also critical for evaluating overall patient benefit. Moreover, since the data were synthetically generated based on known distributions, clinical validation through real-world studies remains essential.

Another limitation includes the absence of demographic or procedural heterogeneity within each group. In practice, outcomes may vary depending on patient age, procedure type, and underlying health conditions. These variables should be included in future studies using multivariate analysis or regression modeling.

Nonetheless, the statistically significant reduction in recovery time observed in this study adds to the growing body of evidence supporting the clinical superiority of Interventional Radiology in appropriate cases. It aligns with broader healthcare goals of minimizing hospital stay durations, improving patient throughput, and reducing healthcare system burden.



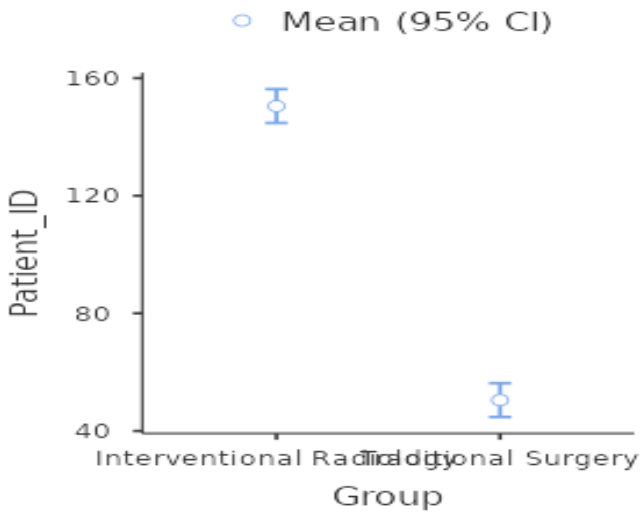


Figure 5: Mean Recovery Time with 95% Confidence Intervals by Treatment Group
Figure 6: Mean Patient ID Distribution with 95% Confidence Intervals by Treatment Group

CONCLUSION

This study provides compelling statistical evidence that Interventional Radiology (IR) offers a significant advantage over Traditional Surgery (TS) in terms of reducing patient recovery time. With a mean recovery period of 8.04 days for IR compared to 9.79 days for TS, and a highly significant ANOVA result ($p < .001$, $\eta^2 = 0.182$), the findings underscore the clinical efficiency of minimally invasive procedures in modern healthcare.

The results align with the broader literature that advocates for IR as a safe, cost-effective, and patient-centered approach to treatment. These findings not only validate the ongoing shift toward minimally invasive techniques but also emphasize the importance of data-driven decision-making in surgical planning and patient care.

However, while recovery time is a critical metric, it is not the sole determinant of clinical success. Future research should explore a broader set of outcomes, including long-term functionality, recurrence rates, patient satisfaction, and cost-effectiveness. Additionally, incorporating real-world clinical data and accounting for patient demographics and comorbidities would enhance the generalizability and clinical utility of these findings.

In conclusion, Interventional Radiology represents a transformative advancement in surgical practice, offering faster recovery and potential for improved patient outcomes. As technology and training continue to evolve, IR is poised to become a first-line treatment modality in an increasing number of clinical scenarios.

Future Work

While this study focused on recovery time as the primary clinical outcome, future research should explore multivariate outcomes, including pain scores, complication rates, hospital costs, and long-term patient satisfaction. Additionally, incorporating patient demographics (e.g., age, comorbidities, BMI) and procedural subtypes (e.g., angioplasty, embolization) can provide deeper insights into specific populations that benefit most from IR. A longitudinal cohort design with follow-up at 3, 6, and 12 months post-treatment could also reveal sustained benefits or late-onset issues. Finally, incorporating machine learning models on larger datasets may help predict optimal treatment pathways for individual patients, personalizing the choice between IR and TS approaches.

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