



Minimally Invasive Surgical Stabilization of Rib Fractures (MI-SSRF) Shortens Hospital Length of Stay and Reduces Complications



Hon Lok Lo^{1,2*}; Dong-Lin Tsai³; Cheng-Chang Lu^{1,4}

1. Department of Orthopedics, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan
2. Ph.D. Program in Biomedical Engineering, College of Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan
3. Division of Chest Surgery, Department of Surgery, Kaohsiung Municipal Siaogang Hospital, Kaohsiung, Taiwan
4. Department of Orthopedics, Kaohsiung Municipal Siaogang Hospital, Kaohsiung Medical University, Kaohsiung, Taiwan

* Email: 980287@kmuh.org.tw

Take Home Message

- **Minimally Invasive Surgical Stabilization of Rib Fractures (MI-SSRF)**, compared to the conventional approach, notably reduced **hospital length of stay (HLOS)**, **operation time**, and **blood loss**. Nevertheless, **ultra MI-SSRF (uMI-SSRF)** achieved even greater enhancements in the abovementioned clinical and surgical outcomes.
- Patients operated with the conventional SSRF had a **5.43 more days of hospitalization**, than those received the uMI-SSRF.
- **MI-SSRF and uMI-SSRF** both significantly **reduced complications** including **pneumonia** and **wound infection**, compared to the conventional group.

Introduction

- **Surgical Stabilization of Rib Fractures(SSRF)** is recommended for chest trauma patients with rib fractures. However, whether and how the incision wound size would affect the clinical outcomes remains unclear.
- The purpose of this study is to examine the effects of three SSRF surgical approaches based on the incision wound size (uMI-SSRF, MI-SSRF, Conventional), on their clinical outcomes and surgery related complications.

Materials and Methods

- This retrospective study examined three SSRF surgical approaches on rib fracture patients who met surgical indications at our hospital from 2016-2023.
- We then categorized the patients based on wound size as the following categories: **ultra minimally invasive SSRF (uMI-SSRF, < 7 cm)**, **minimally invasive SSRF (MI-SSRF, ~7-13 cm)**, and the **conventional SSRF (>13 cm)**.

Figure 1: Flow Chart

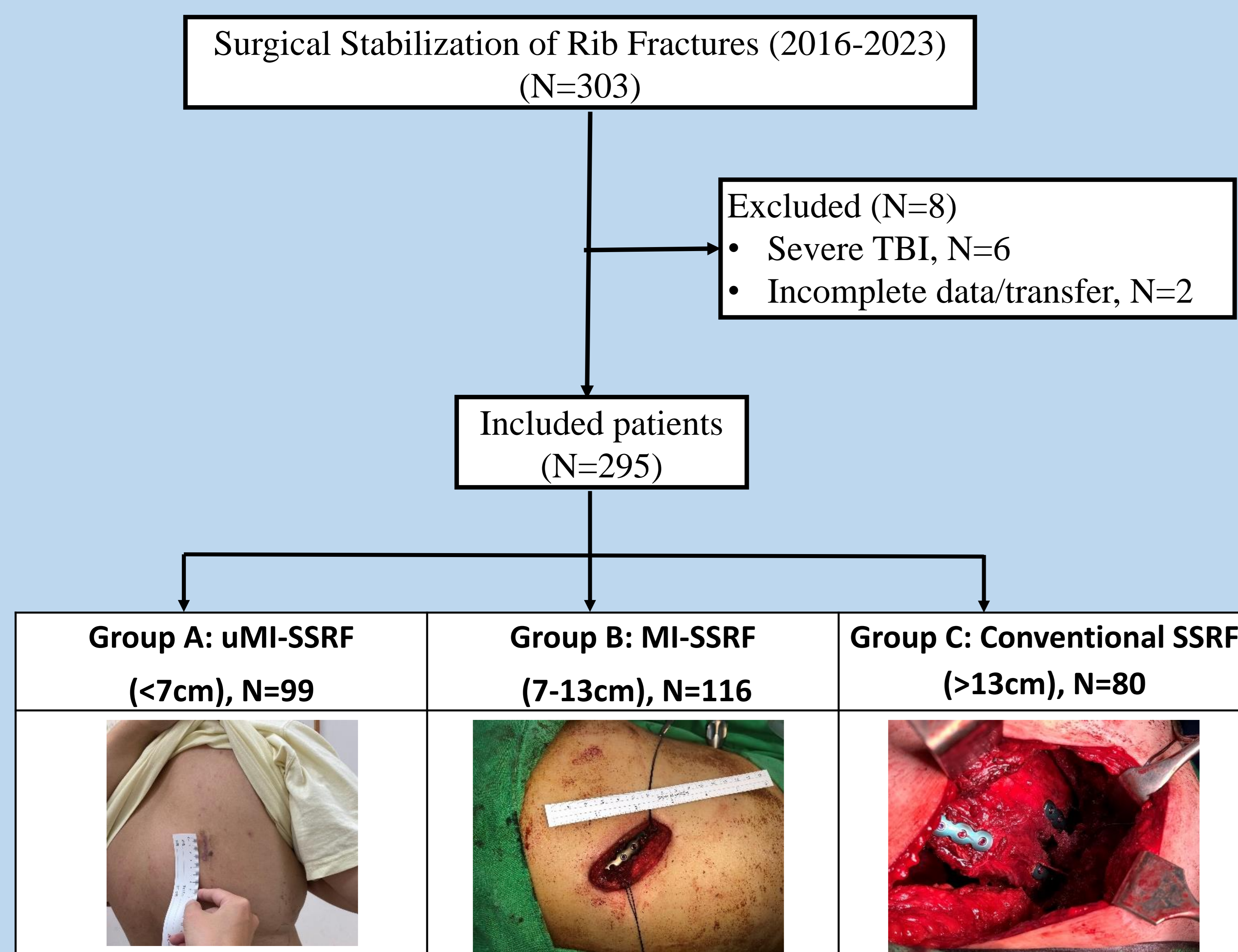


Table 1: Characteristics for three groups

	Total	Wound Size			P value
		A (<7 cm)	B (7-13 cm)	C (>14 cm)	
n	295	99	116	80	
Age, median (IQR)	58.0 (48.0-66.0)	58.0 (50.0-67.0)	58.5 (49.0-66.5)	57.0 (46.0-62.0)	0.3404
Sex male, n (%)					
Males	201 (68.1)	70 (70.7)	78 (67.2)	53 (66.3)	
Females	94 (31.9)	29 (29.3)	38 (32.8)	27 (33.8)	0.8118
BMI, median (IQR)	24.3 (22.2-27.7)	24.2 (22.3-27.3)	23.9 (22.2-26.6)	25.6 (22.5-28.3)	0.1246
Smoking, n (%)					
Nonuse	210 (71.2)	70 (70.7)	87 (75.0)	53 (66.3)	
Use	75 (25.4)	25 (25.3)	27 (23.3)	23 (28.8)	
Quit	10 (3.4)	4 (4.0)	2 (1.7)	4 (5.0)	0.5720
Injury Mechanism, n (%)					
Motorvehicle collision	233 (79.0)	80 (80.8)	88 (75.9)	65 (81.3)	
Fall from Heights	30 (10.2)	6 (6.1)	17 (14.7)	7 (8.8)	
Ground Fall	19 (6.4)	7 (7.1)	7 (6.0)	5 (6.3)	
Fall from Stairs	8 (2.7)	4 (4.0)	3 (2.6)	1 (1.3)	
Direct contusion(hit)	2 (0.7)	1 (1.0)	1 (0.9)	0 (0.0)	
Contusion by machine	3 (1.0)	1 (1.0)	0 (0.0)	2 (2.5)	0.4799
Injury Severity Score (ISS), median (IQR)*	20.0 (17.0-24.0)	20.0 (17.0-22.0)	20.0 (16.0-21.0)	20.5 (17.5-29.0)	0.0362
Flail Chest, n (%)					
No	148 (50.2)	52 (52.5)	64 (55.2)	32 (40.0)	
Yes	147 (49.8)	47 (47.5)	52 (44.8)	48 (60.0)	0.0973
Rib Fracture Side, n (%)					
Left	162 (54.9)	57 (57.6)	62 (53.4)	43 (53.8)	
Right	111 (37.6)	36 (36.4)	44 (37.9)	31 (38.8)	
Bilateral	22 (7.5)	6 (6.1)	10 (8.6)	6 (7.5)	0.9524
Fixation Fracture Ratio, median (IQR)	0.6 (0.5-0.7)	0.6 (0.5-0.7)	0.6 (0.5-0.8)	0.5 (0.4-0.7)	0.1459

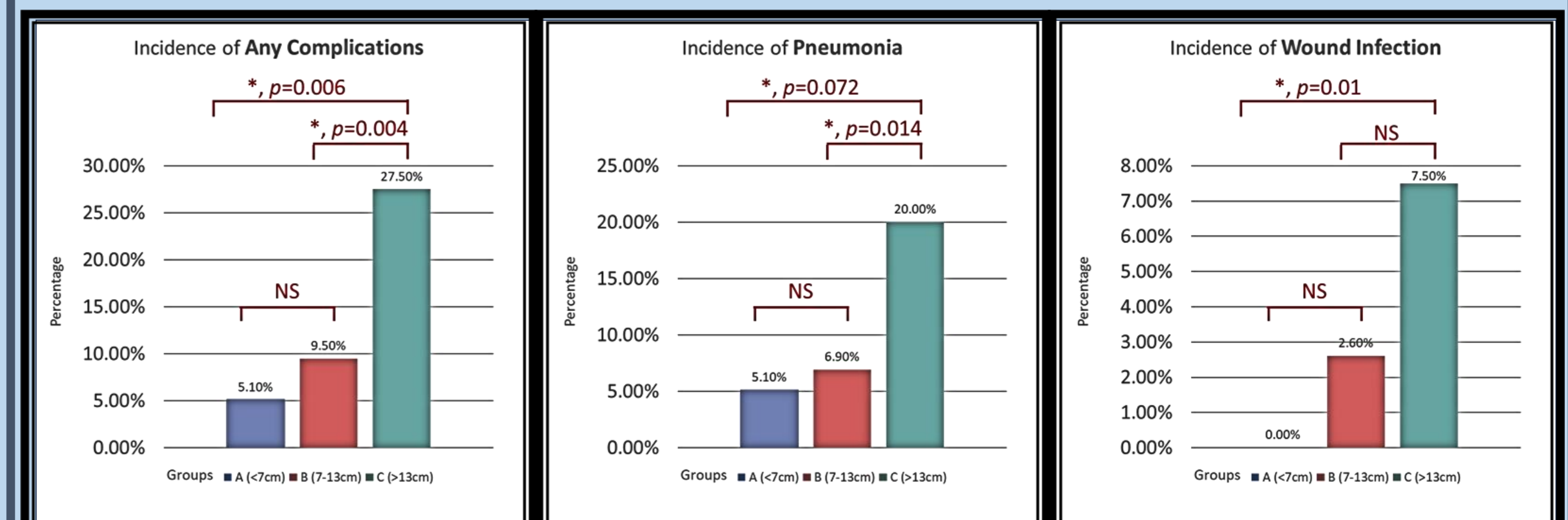
* indicates significant difference among three groups.

Results

Table 2: Overall Outcomes

	Total	Wound size			P value	
		A (<7 cm)	B (7-13 cm)	C (>13 cm)		
N	295	99	116	80		
Wound Size, median (IQR)*	9.0 (5.0-15.0)	4.5 (4.0-5.0)	9.9 (8.0-11.0)	17.0 (15.0-23.0)	<0.0001	
Operation time(min), median (IQR)*	150.0 (110.0-200.0)	120.0 (90.0-158.0)	155.0 (120.0-200.0)	195 (152.5-225.5)	<0.0001	
Blood loss, median (IQR)*	50.0 (20.0-120.0)	25.0 (15.0-50.0)	50.0 (20.0-120.0)	100.0 (50.0-275.0)	<0.0001	
ICU patients, n (%)	127 (43.1)	32 (32.3)	41 (35.3)	54 (67.5)	<0.0001	
ICU Length of Stay, median (IQR)*	5.0 (3.0-8.0)	3.0 (2.0-6.0)	4.0 (2.0-9.0)	6.0 (3.0-8.0)	0.0336	
Hospital Length of Stay, median (IQR)*	10.0 (7.0-14.0)	7.0 (6.0-10.0)	10.0 (7.0-13.0)	14.0 (10.0-18.5)	<0.0001	
Mechanical Ventilation, n (%)	58 (19.7)	22 (22.2)	15 (12.9)	21 (26.3)	0.0441	
Mechanical Ventilation Days, median (IQR)*	4.0 (1.0-7.0)	2.0 (1.0-3.0)	4.0 (1.0-10.0)	5.0 (3.0-10.0)	0.0290	
Complications						
Tracheostomy, n (%)	4 (1.4)	0 (0.0)	1 (0.9)	3 (3.8)	0.0976	
Pneumonia, n (%)	29 (9.8)	5 (5.1)	8 (6.9)	16 (20.0)	0.0028	
Wound Infection, n (%)	9 (3.1)	0 (0.0)	3 (2.6)	6 (7.5)	0.0099	
Implant Related Complication, n (%)	4 (1.4)	1 (1.0)	0 (0.0)	3 (3.8)	0.0668	
Mortality, n (%)	5 (1.7)	1 (1.0)	2 (1.7)	2 (2.5)	0.8561	
Any complication	0	257 (87.1)	94 (94.9)	105 (90.5)	58 (72.5)	
≥1	38(12.9)	5 (5.1)	11 (9.5)	22 (27.5)	<0.0001	

Figure 2: Incidence of complications among three groups



- **Wound size, ICU admission, Pneumonia, and ISS significantly contributed to predicting hospital length of stay (Table 3):**

	Outcome= Hospital Length of Stay			
	Crude β (95% CI)	P	Adjusted β (95% CI)	P
Wound_Size				
A (<7cm)	1.00		1.00	
B (7-13cm)	3.14 (0.45 to 5.83)	0.0223	3.05 (0.77 to 5.32)	0.0086
C (>13cm)	9.27 (6.31 to 12.23)	<0.0001	5.43 (2.82 to 8.04)	<0.0001
ICU admission	9.20 (6.97 to 11.43)	<0.0001	3.39 (0.94 to 5.84)	0.0066
Pneumonia	17.24 (13.65 to 20.83)	<0.0001	11.95 (8.44 to 15.46)	<0.0001
Flail Chest	4.18 (1.79 to 6.57)	0.0006	1.79 (-0.21 to 3.78)	0.0792
ISS, per SD increase	4.22 (3.10 to 5.34)	<0.0001	1.75 (0.58 to 2.93)	0.0035
Fixation Fracture Ratio, per SD increase	-1.78 (-2.99 to -0.57)	0.004	-0.14 (-1.17 to 0.89)	0.7895

- **Wound size significantly reduced the hospital length of stay (Table 3) but was not significantly related to the ICU length of stay (Table 4):**

	Outcome= ICU Length of Stay			
	Crude β (95% CI)	P	Adjustedβ (95% CI)	P
Wound Size				
A (<7cm)	1.00		1.00	
B (7-13cm)	1.73 (-1.26 to 4.72)	0.2560	1.60 (-0.87 to 4.06)	0.2044
C (>13cm)	3.09 (0.26 to 5.91)	0.0321	1.94 (-0.41 to 4.29)	0.1058
Pneumonia	8.67 (6.32 to 11.03)	<0.0001	7.89 (5.54 to 10.23)	<0.0001
Flail Chest	1.86 (-0.47 to 4.19)	0.1169	1.49 (-0.43 to 3.41)	0.1276
ISS, per SD increase	1.61 (0.62 to 2.59)	0.0014	0.88 (0.01 to 1.74)	0.0471
Fixation Fracture Ratio, per SD increase	-0.65 (-1.90 to 0.61)	0.3120	-0.22 (-1.26 to 0.82)	0.6778

Conclusion

- **uMI-SSRF** presents a promising surgical technique offering additional benefits for chest trauma patients with rib fractures. Surgeons should be meticulous in minimizing soft tissue damage as much as they can when performing SSRF.