ORIGINAL ARTICLE

RIB FIXATION VERSUS CONSERVATIVE MANAGEMENT OF RIB FRACTURES IN TRAUMA PATIENTS

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Background: 10–15 % of trauma patient has chest injuries. There is a paradigm shift in the last two decades towards rib fixation from conservative management. Rib fixation results in immediate pain reduction in patients. Although rib fixation shows promising results, conservative management is still preferred. **Methods:** The study was carried out in CMH Lahore from Jan 2017 to March 2018. It was a Controlled Prospective study. Convenient sampling was used. 43 patients are included in the study. Patients with four or more fracture ribs were included. Patients followed at one, two and three months with spirometry/X-ray /clinical response. Rib fixation was done in 21 patients while 22 were managed conservatively. Patients were given choice of both the management options and treated as per their choice resulting in two groups. **Results:** Mean age of patients is 51.35 years. Majority of them were males (86.05%), had haemothorax as confirmed with CT scan (69.80%) and unilateral fracture (79.10%). 7.40% have flail segment. Operative group shows statistically significant improvement in the recovery to work and less post-operative pain when compared to control group. There were no statistical differences among variables such as pre-operative severity and pain index, length of hospital stay, number of days for ventilator support and post op FEV1. There is statistically significant reduction in pneumonia (p <0.05), Acquired respiratory distress syndrome (ARDS) (p <0.05), ventilatory support greater than 1 day (p < 0.05) but there is no statistically significant reduction in **Conclusion:** Rib fixation should be performed early after trauma as it decreases pain, lessens complications and facilitate early recovery to work.

Keywords: Rib fractures; Titanium plates; Fixation; Trauma

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INTRODUCTION

Trauma is a new epidemic worldwide.[1,2] Polytrauma is increasing with the increasing number of motor vehicles on the roads. 10–15%[3] have chest injuries and 25 % of them succumb to death due to chest injuries. By 2030 road traffic accidents are going to be the 5th leading cause of death.[4]

Rib fractures results in pain and loss of tidal volume, paradoxical movement of chest wall, respiratory failure, pneumonia, ARDS, increased intrapulmonary shunt and V/Q mismatch. Rib fractures, either alone or in combination with other injuries causes severe respiratory difficulty and increases the morbidity many folds.

Mortality and morbidity with rib fixation has not been improved in the last four decades.[5] This is due to absence of successful management guidelines. Current management is supportive only consisting of treatment of symptoms only and not treating the underlying cause. Trauma results in multiple injuries and fractures. In contrast to other fractures, ribs fractures are usually managed conservatively.

There are NICE guide lines[6], Orlando medical centre guideline and EAST practice medicine guidelines[5] for the management of rib fractures. According to NICE guidelines[6] surgical stabilization with metal rib reinforcements aims to allow earlier weaning from ventilator support, reduce acute complications, and avoid chronic pain.

According to Orlando medical centre level 2 guidelines[7] surgical stabilization should be considered in patients with flail chest, severe chest wall deformity and symptomatic fractures of three or more ribs. According to EAST[5] practice medicine guideline rib fixation has a role in flail chest patients and during weaning off from the ventilator.

Various scoring systems[8] have been developed to predict the morbidity caused by rib fractures. These include chest wall trauma scoring system, chest scoring system and rib score. These scoring systems helps to stratify the patients with rib fractures which helps in their management.

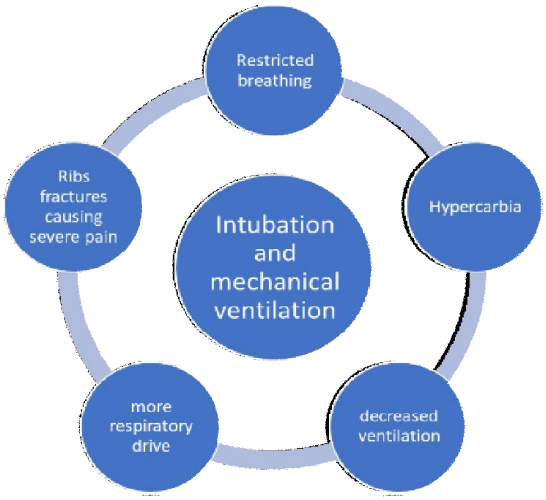

Figure-1: Rib Fractures: a vicious cycle

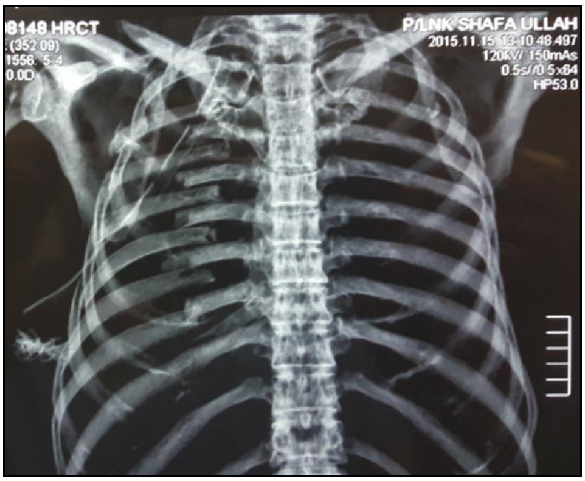

Figure-2: CT scan chest with 3 D reconstruction showing multiple rib fractures

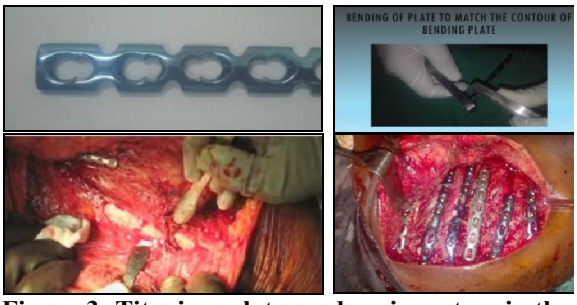

Figure-3: Titanium plates and various steps in the procedure

Rib fractures had been management by various approaches in the past. Greek physician Soranous[9] resected depressed ribs for the relief of pleuritic pain. French surgeon Pare[10] advised the closed reduction of fractured ribs. World war II who were managing rib fractures by resecting ribs driven into the lungs[10]10 A vary described the splinting of rib fractures by internal pneumatic stabilization using tracheostomy and mechanical ventilation.[11,12] Drinker respirator(also known as iron lung),strapping and sandbagging was described by various physicians.[13–16] Fixation with metal wires or sutures after open reduction was also described.[16,17] Different modalities for the management of rib fractures are shown in figure-4.

Use of plates was first described by Siller in 1961.[18] Titanium plates were first utilized by Labitzke[19] Paris[20], Labitzke[19], Judet[21] and Sanchez[22] were one of first few plating systems. Some of the modern systems include Ribloc R, Stratos and Matrix systems.

Most of the tertiary care hospitals treat rib fractures conservatively. It includes pain management via various methods such as potent analgesics, epidural anaesthesia, strappings, ventilator support, intercostal nerve block and chest toilet. Poor results due to prolonged bed rest, immobility and wound problems. Operative management is rarely considered but in few cases. Patient falls in the vicious cycle of pain, respiratory distress and more respiratory effort and more pain. This ultimately results in respiratory depression and sometimes requirement of ventilation as shown figure-1.

Rib fixation with metal implants involves the reduction of broken ribs and stabilization with resulting decrease in pain. This results in improved mechanics of ventilation and expansion of lungs.

The procedure is not very different from other plating procedures except that it involves chest cavity with increased chance of lung injury during the procedure. As ribs are flexible arches of spongy bone, plating systems devised are also bendable.

The objective of the study is to identify the role of rib fixation in early and late pain, hospital stay, ICU stay, functional lung capacity, pulmonary infection, recovery to work place and to identify the complications associated with rib fixation.

MATERIAL AND METHODS

The study was carried out in CMH Lahore from January 2017 to March 2018. It was a Controlled Prospective study. Convenient sampling was used.43 patients are included in the study. Blunt chest trauma patients from 16 years to 80 years. Patients with four or more than four ribs were included. Patients followed at one, two and three months with spirometry/ X-ray/ clinical

response. Convenient sampling technique was used. There were total 43 participants, with 21 (48.84%) belonging to the intervention group and 22 (51.16%) to the control group.

Patients were given choice of either of the options and given treatment accordingly, resulting in two groups. All patients were given adequate education about both the management options and written informed consent obtained for the either of the options and inclusion in the study which was approved from the hospital review board

The inclusion criteria was described as blunt trauma chest patients having four or more ribs fractured, flail segment patients without ARDS, patients with displaced rib fractures causing severe pain and early lung contusions with deteriorating pulmonary functions. Patients with severe head injury (GCS <13), spinal injury and those with age less than 16 are excluded from the study.

Evaluation of patients was done with history, physical examination, pain visual analogue scale, CT scan chest with 3 D bone reconstruction (figure 2) and spirometry. Patients were adjusted in the coming operative list. Per operative vats is used as both diagnostic and therapeutic modality in operative arm.

Patients in conservative arm were treated with pain management, pulmonary toilet, oxygen support and ventilatory support if required.

Video assisted thoracoscopy (VATS) was performed in all patients before undertaking rib fixation. Haemothorax drained and condition of lungs examined. Incision was tailored according to the site and pattern of rib fractures. Some of the patients required an additional small incision for the fixation of flail segment. Posterolateral thoracotomy incision was used in most of the patients. Open reduction and internal stabilization with titanium plates was performed. Post operatively patients were monitored by pulse oximetery, CBC (complete blood count), RFTS (renal function tests), LFTS (liver function test), electrolytes and ECG (electrocardiogram). X-ray was carried out on the same day and incentive spirometry started on next day.

Plates used for rib fixation are customized titanium plates similar to pelvic recon plates. Thickness 1.9 mm, Width 10 mm ,4–14 holes plates. Plates are fixed with locking screws. Five holes plate is mostly used but longer plates can be used for multiple fractures of same rib. Figure 3 shows the metal plate and different steps of the procedure.

Procedure is performed in one lung ventilation. Incision is planned according to the site and number of rib fractures. 3d reconstruction and VATS helps to plan the incision. Rib fracture are then identified and reduction done. Bending template applied and plate bent to match the contour of template. Contoured plate placed over rib and held in placed to be drilled and fixed with locking screws. We use depth gauge to identify appropriate screw length. Depth limited drilling is always used to protect the intra thoracic structures. Chest tube placed in thoracic cavity and redivac drain placed in soft tissue.

Patients followed for three months with monthly visit. Pain reduction, recovery to work place and lung condition were assessed. Pulmonary function tests (PFTs) were carried out at discharge to assess the functional capability of lungs. Pain reduction in patients is assessed by visual analogue scale (VAS), who are asked to quantify their pain on the scale from 1 to 10 pre and post operatively.

Patients are followed for three months with monthly visits which included assessment of pain using VAS, X-ray chest, PFTs and looking for any complications and asked about return to work.

RESULTS

All data were analysed in SPSS v.20 (IBM, Chicago, IL). Categorical variables were reported as frequencies and percentages and quantitative variables as median and range. A series of Mann-Whitney U test were run to analyse statistical significance of between group differences among intervention and control group.

There were total 43 participants, with 21 (48.84%) belonging to the intervention group and 22 (51.16%) to the control group. The participants reported a mean age of 51.35 years and range is 17–84 (SD=13.75). Majority of them were males (n=37, 86.05%), had haemothorax as confirmed with CT scan (n=30, 69.80%), unilateral fracture (n= 34, 79.10%), and did not have a flail segment (n= 32, 74,4%). Detailed results are presented in table-1. Table-2 presents the median and range of outcome variables among the intervention and control groups.

Mann-Whitney U- test revealed that the intervention group reported returning to their work routine in fewer days ($p< 0.001$), less severe post-operative pain ($p=0.032$) and pain index ($p=0.005$) when compared with control group. The present analysis also revealed that there were no statistical differences among intervention and control group on variables such as pre-operative

severity and pain index (p>0.05), length of hospital stay (p>0.05), number of days for ventilator support (p>0.05), FEV1 at discharge (p>0.05), and from 1 to 3 months post operation (p>0.05), and effect on work from 1 to 3 months post discharge (p>0.05). Detailed results including mean ranks, sum of ranks, Mann-Whitney U statistic, Z-score and P-values are presented in table 2 and 3.

Mean pain index at preop in operative group and conservative group was 8.6 and 8.8 respectively which was significantly reduced to 3.6 postop as compared to conservative group where it reduced to only 5.5 as shown in table-4.

Chi square test shows that there is statistically significant reduction in pneumonia (p <0.05), Acquired respiratory distress syndrome (ARDS) (p <0.05), ventilatory support greater than 1 day (p < 0.05) but there is no statistically significant reduction in mortality as shown in table-5.

Table-1: Characteristics of participants (n=43)

	Subcategories	Frequency (n)	Percentage (%)	Mean	Standard Deviation
Group	Intervention	21	48.8		
	Control	22	51.2		
Age				51.35	13.75
Sex	Male	37	86.05		
	Female	6	13.95		
CT findings of rib fracture	4.00	7	16.3		
	5.00	11	25.6		
	6.00	12	27.9		
	7.00	6	14.0		
	8.00	2	4.7		
	9.00	2	4.7		
	10.00	2	4.7		
	17.00	1	2.3		
CT finding Haemothorax	Yes	30	69.8		
	No	13	30.2		
Type of Fracture	Unilateral	34	79.1		
	Bilateral	9	20.9		
Flail Segment	Yes	11	25.6		
	No	32	74.4		
BMI				25.46	4.55

Table-2: Median and range of outcomes among the intervention and control group (n=43)

Variable	Group			
	Intervention		Control	
	Median	Range	Median	Range
Pain Severity_PreOp	3.00	1.00	3.00	1.00
Pain Index_PreOp	9.00	6.00	9.00	4.00
Smoking History in pack years	.00	62.50	.00	60.00
Hospital Stay Total	12.00	28.00	8.50	51.00
Ventilatory support in no. of days	.00	1.00	.00	10.00
FEV1_Discharge	1.74	1.75	1.67	2.02
FEV1_1month	2.19	2.53	2.27	2.65
FEV1_2months	2.55	3.15	2.51	3.74
FEV1_3months	2.64	3.00	2.34	3.17
return_to_work	1.00	2.00	3.00	2.00
Effect on Work_1 month	3	2	4	3
Effect on Work_2 month	3	3	3	3
Effect onWork_3 month	2	2	2	3
fev1_general_discharge	3.00	2.00	4.00	3.00
fev1_general_1st month	3.00	3.00	2.50	3.00
fev1_general_2nd month	1.00	3.00	2.00	3.00
fev1_general_3rd month	1.00	3.00	1.00	3.00
fev1percentage_discharge	60	77	57	63
fev1percentage_1st month	74	105	74	73
fev1percentage_2nd month	93	83	84	101
fev1percentage_3rd month	97	95	84	80
Pain Index_Post Op	4.00	6.00	6.00	8.00
Pain Severity_Post Op	2.00	1.00	2.00	2.00

Table-3: Between group statistical differences on outcome variables among intervention and control groups (n=43)

Variable	Group	Mean Rank	Sum of Ranks	Mann-Whitney U statistic	Z-score	*p*-value
Age	Intervention	24.31	510.50	182.50	-1.18	0.24
	Control	19.80	435.50			
BMI	Intervention	21.19	445.00	206	-0.10	0.92
	Control	20.80	416.00			
Severity of pain (Pre-op)	Intervention	22.48	472.00	221	-0.55	0.58
	Control	21.55	474.00			
Pain Index (Pre-op)	Intervention	21.10	443.00	212.00	-0.51	0.61
	Control	22.86	503.00			
Smoking History in pack years	Intervention	22.10	464.00	208	-0.36	0.72
	Control	20.90	439.00			
Hospital Stay_Total	Intervention	23.17	486.50	206.50	-0.60	0.55
	Control	20.89	459.50			
Ventilatory support in no. of days	Intervention	19.71	414.00	183.00	-1.58	0.12
	Control	24.18	532.00			
FEV1_Discharge	Intervention	22.05	463.00	188.00	-0.57	0.57
	Control	19.90	398.00			
FEV1_1month	Intervention	20.81	437.00	206.000	-0.104	0.917
	Control	21.20	424.00			
FEV1_2months	Intervention	21.67	455.00	196.000	-0.365	0.715
	Control	20.30	406.00			
FEV1_3months	Intervention	22.79	478.50	172.500	-0.978	0.328
	Control	19.13	382.50			
return_to_work	Intervention	13.14	276.00	45.000	-4.527	<0.001
	Control	29.25	585.00			
EffectOnWork_1month	Intervention	19.95	419.00	188.000	-1.158	0.247
	Control	23.95	527.00			
EffectOnWork_2month	Intervention	22.05	463.00	230.000	-0.026	0.979
	Control	21.95	483.00			
EffectOnWork_3month	Intervention	21.64	454.50	223.500	-0.203	0.839
	Control	22.34	491.50			
fev1_general_discharge	Intervention	19.74	414.50	183.500	-0.771	0.441
	Control	22.33	446.50			
fev1_general_1stmonth	Intervention	20.62	433.00	202.000	-0.217	0.829
	Control	21.40	428.00			
fev1_general_2ndmonth	Intervention	19.29	405.00	174.000	-1.000	0.317
	Control	22.80	456.00			
fev1_GENERAL_3rdmonth	Intervention	20.00	420.00	189.000	-0.626	0.531
	Control	22.05	441.00			
fev1percentage_discharge	Intervention	21.98	461.50	189.500	-0.535	0.593
	Control	19.98	399.50			
fev1percentage_1stmonth	Intervention	20.36	427.50	196.500	-0.352	0.724
	Control	21.68	433.50			
fev1percentage_2ndmonth	Intervention	22.52	473.00	178.000	-0.835	0.404
	Control	19.40	388.00			
fev1percentage_3rdmonth	Intervention	23.40	491.50	159.500	-1.318	0.187
	Control	18.48	369.50			
Pain Index_PostOp	Intervention	15.95	335.00	104.000	-2.797	0.005
	Control	26.30	526.00			
Pain Severity_PostOp	Intervention	17.57	369.00	138.000	-2.144	0.032
	Control	24.60	492.00			

Table-4: Mean of pain scores among intervention and control group (n=43)

Report					
Group		Pain Index_Post Op	Pain Index_PreOp	Pain Severity_Pre Op	Pain Severity_Post Op
Group A	Mean	3.6190	8.6190	2.9524	1.5714
	n	21	21	21	21
	Std. Deviation	1.59613	1.32198	.21822	.50709
Group B	Mean	5.6500	8.8182	2.9091	2.0000
	n	20	22	22	20
	Std. Deviation	2.34577	1.13961	.29424	.64889
Total	Mean	4.6098	8.7209	2.9302	1.7805
	n	41	43	43	41
	Std. Deviation	2.22349	1.22135	.25777	.61287

Table-5: Comparison of complications between two groups

Complication	Pearson Chi-Square value	df	Exact sig.
Pneumonia	5.401[a]	1	0.02
Ventilatory support more than 1 day	5.401[a]	1	0.02
ARDS	7.981[a]	1	0.005
mortality	2.002[a]	1	0.157

Table-6: Complication in operative arm

	Complication in operative arm	Number of patients
1	hyperesthesia	4 patients
2	Restricted shoulder movements	4 patients
3	Upper gastric fullness	3 patients
4	pain	2 patients
5	Chest stiffness	2 patients
6	Pneumothorax at chest tube removal	1 patient
7	Sensation of plate friction while movement	1 patient
8	Seroma	1 patient
9	Surgical emphysema	1 patient

Some of complications which we encountered in operative arm include restricted shoulder movement, persistent pain and hyperesthesia (Table-6). There is no death in operative arm. No patient required extraction of implant. There is no severe surgical site infection and pneumonia in operative arm.

Complications in conservative arm include ARDS, chronic pain pneumonia, increased hospital stay and more ventilatory time. Two of the patients in conservative arm died due to the development of ARDS and resulting respiratory failure (Table-7).

Table-7: Complications in conservative arm

	Complications in conservative arm	No. of patients
1	deaths	2 patients
2	ARDS	5 patients
3	Ventilatory support more than 1 day	5 patients
4	Empyema	2 patients
5	Chronic pain	12 patients
6	Restricted shoulder movement	4 patients
7	atelectasis	4
8	Pneumonia	5

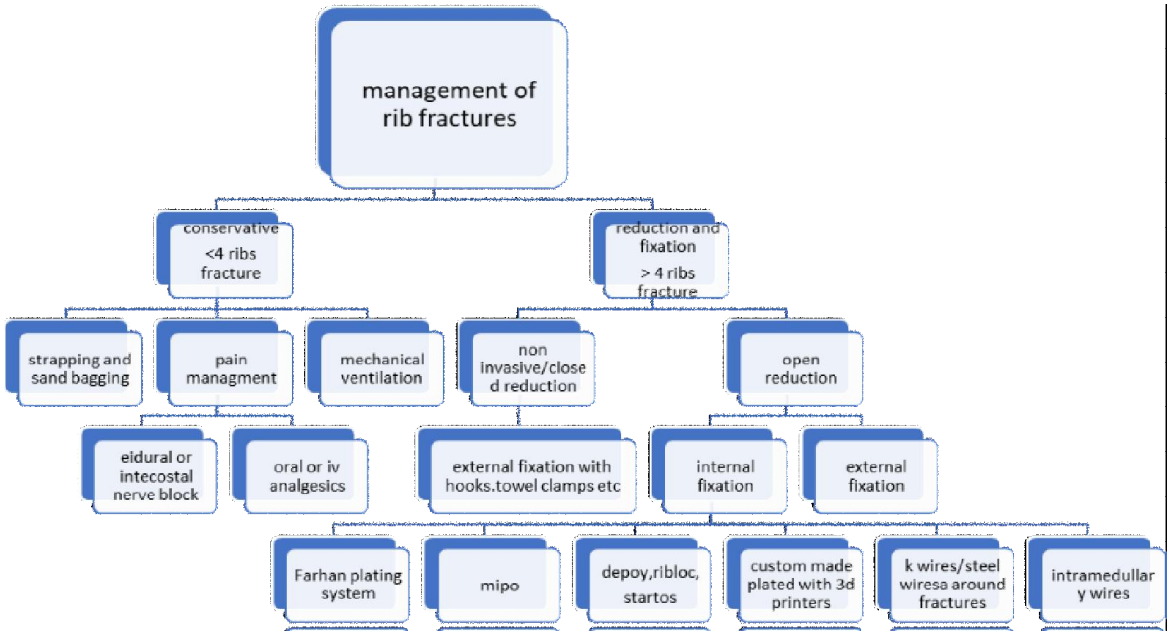

Figure-4: Flow chart for the management of rib fractures.

Table-8: comparison of various studies on rib fixation (Los length of stay, low length of ventilation)

Research	n	Mean ages	surgical procedure	LOS	LOV	ICU stay	Pain reduction	incidence of complications	Return to work place
Tanaka et. al 2002	18 op vs 19 non op	43	Judet struts		10.8 in surgical vs 18.3 in conservative	16.5 days vs. 26.8 days		More in conservative group	61% operative patients returned at 6 months vs. 5% in conservative group
Voggenrieter et al. 1996	20 vs 22		Reconstruction plates		6.5 vs 30.8			More complications and mortality in conservative group	
Granetzny et 2005	20 vs 20	38.2	Internal fixation with intramedullary k wires	11.7 vs 23.1	2 vs 12 days	9.6 vs 14.6		More in conservative group	
Nirula et al. 2006	30 vs 30		Adkins struts and wires	No significant difference (NSD)	2.9 vs 9.4	NSD			
Khandewal et al. 2011	38 vs 29	46	Titanium recon plates	Not assessed	Not assessed	Not assessed	pain in operative group was 9.15, 2.31, 1.12 which was significantly less as compared to 6.25, 5.96, 4.50 in control group on 5th,15th and 30th	Not assessed	Operative group returned to work at 26.6 days compared to 54 .2 days in conservative group
Our experience in CMH	21 vs 22	51.3	Titanium plates	NSD	NSD	Not assessed	Significant reduction in pain in operative group Mean pain index in operative group preop was 8.6 which was reduced to 3.6 as compared to conservative group where mean pain index preop was 8.8 and was reduced to only 5.5 post op	More complications in operative group	It was significantly earlier in operative group

DISCUSSION

Our study reveals the effectiveness of rib fixation in the management of multiple rib fractures. The recovery to work place was 16 days earlier in operative group compared to conservative group. Post op pain reduction was significantly less in operative arm as compared to pain in conservative group at discharge. Pain reduction was marked in early post op period. This helps earlier return of work to work and less post op complications. In our experience pain reduction was greatest during 1st month and at 3rd month it was almost equal in both groups Our results are comparable to other studies in terms of return to work place and early pain reduction (Table-8).

VATS was an important part of our study. It is used to treat haemothorax and pneumothorax as well as it helps us to assess the extent of lung trauma. VATS help us to identify the site and pattern of rib fractures. It has both therapeutic and diagnostic roles

Granetzny[23] *et al*. published in 2005 compared 20 patients who had their ribs surgically stabilized with 20 conservatively managed patients. Findings such as decreased length of ventilatory support days, ICU stay and incidence of complications such as pneumonia was significantly less in operative group.

Metanalysis[24] of operative treatment of rib fractures in flail chest in 2013 showed reduced mortality, respiratory complications and hospital stay in operative group in comparison to conservative

group. Tanaka *et al*. in 2002[25] compared operated patients (Judet struts) with conservative management. ICU stay was significantly lower in operated arm (16.5 days vs. 26.8) days.

Voggenrieter *et al*. 1996[26] compared operated to conservative patients and noted significantly lower length of ventilation (6.5 days vs 26.7 days) in operated patients.

According to Babak's system[27] a patient who has rib fractures as the main injury and has underwent tracheostomy without rib fixation didn't received proper treatment[27]. Morbidity and mortality increase with the increasing age and increasing number of rib fractures.[27–29]

Khandelwal[30] *et al*. found out that there was less pain in operative group as compared to control group. Rib fracture pain in operative group was 9.15, 2.31, 1.12 which was significantly less as compared to 6.25, 5.96, 4.50 in control group on 5th,15th and 30th postop days. Operative group re turned to their work 28 days earlier than conservative group and had fewer complications.

Different studies showed that conservative treatment results in inadequate pain management, chronic pain, late recovery to work and increased hospital stay[25,23]. These findings are consistent with our study which showed poor early pain management, late recovery to work and more complications in conservative group. Recent comparative studies show improved results after surgical stabilization of rib fractures.[25,26,23,9] There are different plating systems for rib fixation and chest wall stabilization. There is markedly reduced length of hospital stay, ICU stay[31], length of ventilation in operated compared to conservative group. For external fixation and stabilization after chest trauma very innovative techniques had been used in the past; Bullet forceps[32], threaded metal hooks of cloth hanger[33], towel clips[34], reduction forceps[13], suction devices like Cape Town Limpet[11,35] were used to fix the fractured chest wall. This is an era of more advanced technology. 3-D printing and use of virtual reality are new innovations in this field.

CONCLUSION

Rib fixation should be performed as early as possible.[27] It causes immediate reduction of pain in multiple rib fractures patients.[27,30] There is early recovery of the patients to their workplace with reduced pain and complications.

RECOMMENDATIONS

There should be more randomized control trials to ascertain the full potential of the rib fixation in poly trauma patients. Guidelines and implants should be standardized. Rib fixation should be considered in multiple rib fracture patients.

New materials are available for rib fixation. New techniques including MIPO should be explored. Fix ribs and fix them early. It is under used modality. Current management is supportive only. More Prospective studies are required for the technique to be accepted.

The operative management is not widely used because of various reasons; unfamiliarity of surgeons and anaesthetist with thoracic procedures, no standard implants and technique, unavailability of implants, no clear guidelines for operative management, other injuries and ventilators masking the morbidity associated with rib fractures, trauma doctors not aware of the mortality and morbidity associated with rib fractures and don't consider of rib fixation.

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