Original Article

The effectiveness of small-bore intercostal catheters versus large-bore chest tubes in the management of pleural disease with the systematic review of literature

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ABSTRACT

Objective: The purpose of this study was to compare the effectiveness of small-bore intercostal catheters (SB ICCs; 10–14 Fr) to large-bore intercostal tubes (LB ICTs; >20 Fr) in the management of pleural diseases. **Methods:** A total of 52 patients (42 males) with a mean age of 55 ± 23 years undergoing pleural intervention were included in the analysis. Twenty-five patients (48.1%) had pneumothorax and rest (51.9%) had pleural effusion. Half of the patients underwent SB ICC (mean age: 63 ± 20 years) and the remaining 26 underwent LB ICT (mean age: 47 ± 25 years). **Results:** SB ICCs were predominantly used in patients with primary pleural effusion and LB ICTs in patients presenting with pneumothorax. Failures were in <20% of SB ICC patients (mainly from loculation) and in <30% with LB ICT patients (from persistent airleak) – difference that was not statistically significant. In both groups, no deaths or major complications directly related to the procedure were observed. However, the proportion that needed surgery was significantly different in two cohorts (18.5% OF SB ICC and 42.3% of LB ICT cohorts). The ICC dwell time was less in SB ICC (5 ± 4 days), compared to LB ICT (8 ± 6 days). SB ICCs were associated with less pain and seem to be tolerated better by the patients. **Conclusions:** In well-supervised tertiary hospital setting, SB ICCs are as effective as LB ICTs with better patient tolerance, reduced dwell time, and reduced likelihood for surgical intervention.

KEY WORDS: Empyema, intercostal drains, pleural disease, pneumothorax, thoracic surgery

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INTRODUCTION

Pleural diseases are common clinical problems encountered worldwide. Operative tube thoracostomy with large-bore intercostal tubes (LB ICT; >20 Fr) has conventionally been the standard of care for several decades. More recently, small-bore intercostal catheters (SB ICC; ≤14 Fr) have become an alternative to LB ICTs. SB ICCs have been found to be equally effective though less painful and better tolerated by the patients. Guidewire-guided placement (Seldinger technique)[1] and ultrasound allows for more accurate positioning reducing human error. However, LB ICTs are still used and remain the method of choice in many hospitals.

Smaller tubes are thought to be less effective because of slower drainage rates and are prone to blockage. Park

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et al.[2] in an *ex-vivo* experiment found that there was no significant difference in drainage time of bodily fluids of differing viscosity with tubes above 8Fr. In another experiment comparing *in-vitro* and *in-vivo* drainage through 19 Fr and 28 Fr tubes found similar rates *in vivo*.[3] The other argument is the cost-effectiveness associated with LB ICTs.

Most studies promoting SB ICCs have been single tube observational studies. Some of the comparative studies, such as Vedam and Barnes,[4] reported a higher prevalence of combined complications and recurrences with the use of the SB-ICCs (42%) than with the LB-ICTs (16%). In TIME 1 study, the largest prospective randomized trial which compared 12 Fr SB ICC with 24 Fr LB ICTs in malignant pleural effusion, showed larger tubes were more effective for pleurodesis, were associated with fewer complications during insertion, and a lower proportion of falling out questioning previous assumptions.[5]

Aims and objective

Current data remain inconclusive and therefore, choice of the tube size remains controversial.[6] With this background, the aim of this study is to evaluate the effectiveness of SB ICCs versus LB ICTs in the management of pleural diseases in our center. We also tried to briefly review the existing literature on topic.

METHODS

This observational study was conducted at a tertiary care university hospital. Fifty-two patients (42 males) with a mean age of 55 ± 23 years who were undergoing pleural intervention were included in the study. The demographic characteristics, diagnosis, indication, intervention, complications, and outcome of the intervention were analyzed. Patients requiring drainage were subjected either to SB ICCs or LB ICTs at the discretion of treating respiratory physicians. All procedures were performed in accordance with stringent hospital procedure protocols and by the experienced respiratory physician or by the supervised trainee. Ultrasound guidance was used when necessary. Patients requiring diagnostic pleural tap and therapeutic pleural drainage were not included in the study.

Initial treatment success was defined as complete resolution of effusion or pneumothorax without ICT/ICC kinking, obstruction, displacement, or needing second intervention such as placement of a second ICT/ICC or surgery.

Twenty-six patients underwent SB ICC (mean age: 63 ± 20 years) and 26 underwent LB ICT (mean age: 47 ± 25 years). The demographic data are detailed in Table 1.

Intervention

The operative tube thoracostomy method was followed for LB ICT,[7] while the modified Seldinger technique[1] was used for SB ICC. Cook catheter set was the most commonly used for SB ICC.

Statistical analysis

The STATA statistical software (STATA v15.0, Stata Statistical Software: Release 14. College Station, Texas, USA) was used for the analysis. The two-sample *t*-test with equal variances was used for age comparisons, while the Pearson Chi-square test was used for others with proportions such as sex, procedural indication, intervention outcome, need for second intervention, need for surgery, and complication rates. The two-sample Wilcoxon rank-sum (Mann–Whitney) test was used to assess differences in dwell time and hospital stay.

RESULTS AND OUTCOME

The most commonly used catheters were 14 Fr and 20 Fr in the SB and LB patient groups, respectively. There was a significant trend toward the insertion of SB ICC in patients presenting with malignant pleural effusion, parapneumonic effusion and in pleural effusions in general while LB ICT was favored in patients presenting with spontaneous pneumothorax and hemothorax [Table 1]. There were two deaths in both groups, but they were palliative end-stage cancer patients. In both groups, no deaths or major complications directly related to the procedure were observed. The total complication rate was significantly higher in the large-bore group (26.9% vs. 23.1% respectively, $P = 0.032$). Position error was the main complication seen in the LB group, while dislodgment was the main complication in the case of small-bore tubes [Table 2].

Almost all patients with LB ICTs complained of pain and need for analgesia, including the use of opiates, which was much higher in this group. The mean duration of analgesia administered in the SB ICC (2 days) was much less than in the LB ICT group (8 days). SB ICCs seem also to be better tolerated by the patients with only 40% needing analgesia.

Table 1: Patients demographics and indication for small-bore intercostal catheter and large-bore intercostal tube

Demographics	SB ICC	LB ICT	*n*	Test	*P*
Mean age	63±20	47±25	52	t=4.1	≤0.001
Male (%)	18 (42.8)	24 (57.1)	42	χ^2=4.5	0.035
Malignant effusion (%)	13 (50	3 (11.6)		χ^2=9.0	0.03
Parapneumonic effusion/empyema (%)	6 (23.1)	1 (3.8)		χ^2=4.1	0.042*
CCF (%)	2 (7.7)	0			
Haemothorax (%)	0	1 (3.8)			
Spontaneous pneumothorax (%)	4 (15.4)	18 (69.2)		χ^2=15.4	≤0.001
Iatrogenic pneumothorax (%)	1 (3.8)	3 (11.6)			≤0.001
ICC/ICT size	6f=1, 8f=3, 14f=22	16f=3, 20f=19, 28f=4			

*Interpret with caution due to small numbers in cell. SB ICC: Small-bore intercostal catheter, LB ICT: Large-bore intercostal tube, CCF: Congestive cardiac failure

The success of both SB ICCs and LB ICTs was comparable with failure rates of 19.2% and 26.9%, respectively [Table 2]. Drain failure was predominantly related to loculated effusion in the SB ICC while persistent air-leak was the main reason for failure in large tube group and these occurred with <20% of patients.

About a third of SB ICC patients and half of LB ICT group needed a second procedure, and rate of surgical intervention was significantly higher in the large-bore tube patients (42.3%) than in those who initially received small-bore tubes (18.5%). The ICC dwell time was noted to be shorter in SB ICC.

DISCUSSION

The study shows a trend toward inserting SB ICCs in patients with primary pleural effusion and LB ICT drains in pneumothorax. The most common indication for SB ICC was malignant pleural effusion. All patients with parapneumonic effusion predominantly received SB ICC. There was only one case of hemothorax which received LB ICC.

In the current study, the success rate with SB ICCs was 74.9%. Other previous published studies have reported variable success rates from 72.9% to 93.7% [Table 3].

The pleural procedure success rates are dependent on the indication and ancillary procedures performed. In our study, loculated effusion was a cause of failure in keeping with a study by Bediwy and Amer.[8] However, in a study by Mehta *et al*.,[9] SB ICC was effective in 94.7%, though 61% of the cohort had loculated effusion. Similar results were noted by Jain *et al*.[10] This appears presumably related to the routine use of intrapleural fibrinolytic therapy (IPFTs) following the MIST-2 trial,[11] but was not a routine practice to install IPFT agents at our center, during this study period. Most patients with loculated empyema are referred for video-assisted thoracoscopic surgery, although recently, we have increased the use of IPFTs with high success rates.

Table 2: Outcome data for the small-bore intercostal catheter and large-bore intercostal tube cohorts

	SB ICC	LB ICT	Test	P
Complication (%)				
Dislodgment	3 (11.6)	1 (3.8)	χ^2=4.6	0.032
Position	1 (3.8)	4 (15.4)		
Judgmental error	1 (3.8)	1 (3.8)		
Pneumothorax	2 (7.6)	0		
Total (all complications)	7 (26.9)	6 (23.1)		
Reason for failure of intervention (%)				
Loculation	4 (15.4)	1 (3.8)		0.158
Persistent airleak	1 (3.8)	5 (19.2)		0.082
Judgmental error	0	1 (3.8)		
Total	5 (19.2)	7 (26.9)		0.51
Need for 2nd intervention (%)	8 (30.7)	13 (50)	χ^2=2.0	0.158
Need for surgery (%)	4 (18.5)	11 (42.3)	χ^2=4.6	0.032
Need for 2nd drain (%)	5 (19.2)	2 (7.6)	χ^2=1.5	0.23
Favorable outcome (%)	80.8	73.1		0.51
Dwell time days	5.2±3.6	8.1±6.5	Z=2.71	0.007
Hospital stay days	16.1±15.4	11.0±7.9	Z=1.32	0.186

SB ICC: Small-bore intercostal catheter, LB ICT: Large-bore intercostal tube

In our study, we did not find a significant difference in success rates between SB ICCs and LB ICTs (74.9% vs. 72%). Similar results have been noted in other studies in terms of efficacy such as Vedam and Barnes,[4] Lin *et al*.,[12] and Krishnakumar *et al*.[13] while higher success rates were also noted with SB ICC among patients with spontaneous pneumothorax in Iepsen and Ringbæk study.[14] Dislodgment as a cause of failure was more common in our study in LB ICT group in comparison to previous studies where it was common in SB ICC group. This was probably related to a higher incidence of inter-hospital transfer in the group. Since the outcome of this study, we have introduced protocols for medical professionals caring for such patients, with noticeable reduction in tube dislodgment rates at our center.

We observed increased need for second intervention and a higher rate of surgical intervention in the LB ICC group (36% vs. 18.5%). Rates of surgical intervention were much higher in our study and may be related to strong cardiothoracic presence in our center or the underlying primary pathology. However, other studies such as Mehta *et al*.,[9] also suggest LB ICT group had higher surgical intervention rates (14.3% vs. 5.3%).

In this study, SB ICC dwell time was noted to be shorter. The overall hospital stay was prolonged in the SB ICC group though not statistically significant. However, this appears rather due to underlying medical condition rather than pleural procedure related. Hussein *et al*.[15] and Benton and Benfield[16] suggest a trend toward a longer period of drainage with the LB ICT, while the studies by Iepsen and Ringbæk,[14] Krishnakumar *et al*.[13] suggest that SB ICC was significantly associated with shorter dwell time. In most studies the median SB ICC dwell time varied between 3 and 7.5 days.[8,10,12-20] In Iepsen and Ringbæk study,[14] shorter duration of hospitalization was also noted in SB ICC group.

In our study cohort, in both groups, no deaths or major complications directly related to the procedure were observed. The findings were similar to that observed in studies by Lin *et al*.[12] It is not uncommon that pleural procedures can be associated with serious life-threatening complications, especially if performed by less experienced personals.[21] In a UK study, a total of 17 fatalities were reported from 2003 to 2008, secondary to pleural procedure.[22]

Vedam and Barnes[4] noted higher complication and recurrence rates with SB ICC. However, most other studies indicate much higher complication rates with LB ICTs such as Benton and Benfield study (32% vs. 24%), Iepsen and Ringbæk study (27.4% vs. 9.5%; $P = 0.026$) and Krishnakumar *et al*. (43.9% vs. 21.66%, $P = 0.001$).[13,14,16]

Table 3: Comparison with other published studies

Study/year/place	Mean±SD or mean				Success rate (%)	
	Hospital Stay with LB ICT (days)	Hospital Stay with SB ICC (days)	LB ICT Dwell time (days)	SB ICC dwell time SB ICC (days)	LB ICTs (%)	SB ICC
Our study Australia	11±8	17±13	8±6	5±4	72	74.9
Hussein *et al*. (2016), Egypt[15]	NA	NA	9.7±2.5	7.2±0.5	63.6	72.7
Krishnakumar *et al*. (2015), India[13]	NA	NA	5.8	4.9 (P=0.023)	53.65	70
Iepsen and Ringbæk (2013), Denmark[14]	11.8	6.9 (P=0.04)	8.3	4.9 (P=0.001)	56.5	85.7 (P=0.002)
Mehta *et al*. (2013), India[9]	13.3±8	13±5.7	9±5.6	9.7±5.7	85.7	94.7
Lin *et al*. children (2011), Taiwan[12]	12.5±5.6	17.3±8.5	6±2.6	5.9±3.8	87.5	83.3
Liu *et al*. (2010), Taiwan[19]	NA	29.23±29.6	NA	6.1±2	NA	72.9
Benton and Benfield (2009), UK[16]	NA	NA	4.7±2	3.3±2	80	88
Jain *et al*. (2006), India[10]	NA	NA	NA	7.5±4.5	NA	92
Bediwy and Amer (2012), Egypt[8]	NA	NA	NA	5.8±2.8	NA	82.35
Vedam and Barnes (2003) Australia[4]	NA	NA	7.0	5.0	65	72
Sabry *et al*. (2012) Egypt[18] (malignant effusion	5.7±2.7	2.1±2.3 (P<0.05)	5.4±2.5	4.5±1.3	96.7	93.3
Liu *et al*. (2003) Taiwan[17]	8.9	8.0	5.2	6.2	72.2	70
Gammie *et al*. (1999), USA[20]	NA	NA	NA	4.1±0.7 (effusion) 3.0±1.9 (pneumothorax)	NA	86 (effusion) 81 (pneumothorax)

NA: Not available, SD: Standard deviation, SB ICC: Small-bore intercostal catheter, LB ICTs: Large-bore intercostal tubes

In Benton and Benfield study,[16] a much higher infection rate was noted with large-bore drains (12% skin and 16% pleural infections vs. none in the small-bore group). Similarly, high rates of infection were seen in another study (27.4% vs. 9.5%, P = 0.026).[14]

In terms of complications, as per BTS guidelines, the incidence of injury with large-bore versus small-bore drains was 1.4% versus 0.2%, the incidence of malposition was 6.5% versus 0.6% while the incidence of empyema was 1.4% versus 0.2%. However, the incidence of drain blockage was 5.2% with large tubes versus 8.1% with small drains.[7] The lower major complication in our study is presumably related to procedures being performed by experienced physicians and trainees.

In our study, 40% of SB ICCs needed analgesia for median of 2 days. In comparison, all patients with LB ICTs needed analgesia for a median of 8 days. This has been confirmed in other studies such as Sabry *et al.*,[18] Lin *et al.*,[12] Jain *et al.*,[10] Cafarotti *et al.*,[23] and Horsley *et al.*[24] It appears logical as a 32 Fr chest tube which has an outer diameter of 10.7 mm will impinge neurovascular bundle causing pain in contrast to SB ICC (≤14 Fr) with diameter ≤4.7 mm.

Considering the increased patient tolerance of SB ICCs, it is becoming a method of choice for long term management of malignant pleural effusion. Studies by Lambert and Gurgacz (ASERNIP-S),[25] Fysh *et al.*,[26] Saffran *et al.*[27] and Musani *et al.*[28] indicate small-bore catheters provide an efficacious yet cost-effective, minimally invasive outpatient approach compared to other strategies. A review of tunneled pleural catheters in adults with malignant pleural effusions found 19 studies with a total of 1370 patients which showed improved outcome and without any major complications.[29] In the study by Putnam *et al.*,[30] the median hospitalization time was 1 day for Pleurex patients.

The BTS guidelines recommend that an SB ICC are adequate for most cases of complicated parapneumonic effusion, though there is no consensus on the optimal size.[31] Rahman *et al.*[32] reviewed 405 patients who participated in the Multi-center Intrapleural Streptokinase Trial[33] and reported that there was no significant difference in the frequency of death or need for thoracic surgery in patients receiving chest tube of varying sizes (<10 Fr, 21/58 (36%); size 10–14 Fr, 75/208 (36%); size 15–20 Fr, 28/70 (40%); size >20 Fr, 30/69 (44%); (P = 0.27).

In traumatic pneumothorax, if it is non-occult, chest tube is needed while in occult pneumothorax, drain is needed only if they are on mechanical ventilation. In all such situations, small-bore drains are recommended initially.[34]

There are certain situations where large-bore tubes are warranted.

Lin *et al.*[35] did a retrospective review of mechanically ventilated patients who underwent pigtail catheter drainage as their initial therapy for pneumothorax. They found pigtail catheter drainage as relatively effective in treating iatrogenic pneumothorax (due to thoracentesis, the insertion of an indwelling line) with success rate of 87.5% but less promising for barotraumatic pneumothoraces with success in only 43.3% cases.

LB ICTs are recommended for haemothorax. The reason for the recommendation is the blood may contain clots and the volume may be too large. However, there is some data available suggesting smaller drains appear to be as effective.[36,37] Massive hemorrhage (>1500 mL) or continued drainage of more than 250 mL/h for 4 h though will necessitate the need for surgical intervention.

Our study had some limitations. It was an observational study conducted in a tertiary care referral center with differences in local practice limiting the generalizability of the conclusion. The study was not randomized and the decision to insert SB ICC or LB ICT was solely based on treating clinician's discretion. It may have led to selection bias. Interpretation of the findings may also be affected by variations in the diagnosis between the SB and LB groups. We did not use Intrapleural fibrinolytic therapy, which may have affected the success rates and introduced bias. Further, even though, the standard of care given to the patients in LB ICT and SB ICC was similar in both groups, blinding was not possible considering the nature of the study. The authors acknowledge that this is a very small sample size of patients to advocate firm opinion or conclusion; however, it adds to the limited pool of knowledge in the literature. A large randomized controlled trial with patient stratification based on indication and with a standardized pre- and post-drain care protocol is warranted to help reduce these confounding factors.

CONCLUSION AND AREAS OF FURTHER RESEARCH

In our study, SB ICCs and LB ICTs were similarly effective with success rates of 74.1% and 72%, respectively. SB ICCs were better tolerated with respect to pain and mobility postprocedure. Higher rate of surgical intervention, need for second intervention and longer ICC dwell times were noted in LB ICT group.

With the availability of pleurex catheter, SB ICCs are becoming method of choice in the management of malignant pleural effusion. Intrapleural fibrinolytic therapy has increased the success rate of SB ICC in complicated para-pneumonic effusion. Therefore, small-bore catheter should be considered primary choice in malignant pleural effusion, pneumothorax (except in mechanically ventilated patients), as the parapneumonic effusion/empyema and when pleurodesis is intended. The success of the SB indwelling tunneled catheters suggests that the SB ICC does not commonly become obstructed with fibrin. Imaging guidance must be advocated irrespective of the drain size used. Patients on mechanical ventilation with barotrauma-induced pneumothoraxes are best managed with large-bore chest tubes. The role of small-bore drains in traumatic hemothorax and major thoracic surgery has not been tested and are best managed presently with large-bore catheters.

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