Review Article

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Chest drain size: Does it matter?

David J McCracken, Ioannis Psallidas, Najib M Rahman

Abstract:

Pleural disease is common with an increasing incidence and so represents a significant proportion of the workload for respiratory physicians. Chest drain insertion continues to be considered a mainstay of pleural disease management however the optimum drain size required for various pleural conditions remains unclear. Traditionally large-bore chest drains were inserted through a surgical technique of blunt dissection however smaller bore Seldinger (guidewire) drains have dramatically increased in popularity in recent times most likely due to ease of insertion and perceived increased patient tolerability. Despite British Thoracic Society Guidelines advocating a preference for small-bore chest drains, their use remains controversial. We aim to review the literature in each category of pleural disease including pneumothorax, malignant pleural effusion and pleural infection, regarding chest drain size, comparing the role, effectiveness and complications of each.

Keywords:

Chest drain, empyema, malignant pleural effusion, pneumothorax

Background

Pleural disease is common and affects over 3000 people/million population/year, translating to almost 200,000 new cases in the UK annually.[1] This represents a significant health-care burden and a substantial proportion of the workload of respiratory physicians. Chest drain insertion is a common procedure required in the treatment of pleural disease, and the incidence of symptomatic pleural disease requiring intervention such as this is increasing. The frequency of pleural infection has doubled over a 10-year period and is continuing to rise.[2,3] With annual increases in cancer incidence of 100,000 cases/year by 2025, the frequency of pleural metastatic disease resulting in malignant pleural effusion is also rising, as is the projected incidence of mesothelioma.[4-6]

Conventionally, large-bore chest drains have been inserted through a surgical technique using blunt dissection, however the use of small-bore chest drains (i.e., ≤20Fr), often inserted using a Seldinger technique, has significantly increased in recent times. This is likely related to ease of insertion, reduced trauma and the perception of diminished patient discomfort, despite potentially improved drainage from a larger drain.[7] This preference towards the use of small-bore drains is a position further supported by the British Thoracic Society (BTS) Pleural Disease Guideline 2010 that recommended the use of small-bore chest drains in the management of pneumothorax and malignant pleural effusion.[1]

The optimum chest drain size in each pleural condition remains unclear, with potential competing advantages and disadvantages for each condition according to drain size. This review has examined the literature in each major diagnostic category of pleural disease regarding chest drain size, and compared the role, effectiveness and complications of drain size in the management of each condition specifically.

Technical Aspects

Historically, large-bore chest drains have been in use as a first-line intervention in the management of pleural disease. They

Oxford Respiratory Trials Unit, University of Oxford, Churchill Hospital, Oxford, UK

Address for correspondence:
Dr. David J. McCracken, Oxford Respiratory Trials Unit, University of Oxford, Churchill Hospital, Oxford, UK.
E-mail: dmccracken04@qub.ac.uk

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remain first line in the management of traumatic thoracic and pleural disease in keeping with expert consensus, however recent evidence calls this expert opinion into question.[8] A retrospective study by Kulvatunyou *et al*. demonstrated similar duration of treatment between small bore, pigtail drains when compared with large-bore drains in traumatic pleural disease and only a modest, non-statistically significant increase in drain failure rate defined as the need for a further pleural procedure.[9] The same authors also performed a small, randomized controlled trial of 40 patients assessing differences in pain perception between small-bore pigtail drains and large-bore drains. Although underpowered, the secondary outcomes showed similar success rates in the management of traumatic pneumothorax.[10]

A recent review also casts doubt on the requirement for large-bore drains in hemothorax and suggests further prospective studies are required.[11] There remains the view that larger bore drains are necessary to allow adequate drainage of viscous materials or for a significant air leak, however evidence in support of this rationale is largely anecdotal and contrary to current BTS guidelines.[1,12]

Several recent studies have concluded that large-bore drains are associated with increased pain, a feature that is most likely related to a more traumatic insertion technique and larger tissue injury.[12,13]

The risk of visceral injury, malposition, and infective complications (empyema) are all considered to be potentially higher with larger drains, however, separating out the insertion technique (blunt dissection with a "finger sweep" versus the now widespread use of thoracic ultrasound to guide smaller bore drains) is challenging, and whether the size of drain is related to potentially increased complications rather than the technique of insertion is unclear.[1]

In contrast, small-bore chest drains are perceived to have a potentially lower rate of serious complication, which may in part be attributable to the increased use of focused thoracic ultrasound. However, specific studies directly comparing complication rates according to drain size are infrequent, and those published suggest a higher complication rate overall with these drains, with issues such as blockage or dislodgement.[14] Most recently, the Therapeutic Intervention in Malignant Effusion 1 (TIME1) trial which randomized patients to large (24Fr) versus small (12Fr) drains demonstrated a high fallout rate of 42% with small-bore drains compared with 28% for large-bore drains.[15] Displacement of drains before a clinical decision to remove is a significant event, as this often results in the need for a further pleural procedure with its associated risks and reduction in quality of care for the patient.[14]

Pneumothorax

Pneumothorax describes air in the pleural space, however represents a more complex spectrum of pathology. It is loosely divided into two separate groups – primary spontaneous (PSP) and secondary spontaneous pneumothorax (SSP), with SSP associated with underlying lung disease, whereas PSP is characterized by its occurrence in otherwise healthy patients. This is a somewhat arbitrary distinction, as recent evidence suggests that subpleural blebs and bullae are present in >90% of patients with PSP.[16,17] Those with underlying lung disease are likely to have greater morbidity, poorer tolerance and may in turn be more difficult to manage.[1]

Primary Spontaneous Pneumothorax

PSP is a common clinical problem with a reported incidence of 18–28/100,000 cases per annum for men and 1.2–6/100,000 for women.[18] Risk factors include age, sex, height and smoking status.[1] Not all patients with PSP require intervention and some may be managed with observation alone, particularly those who are asymptomatic.[1] In those who do require intervention, aspiration has been shown to be as effective as drainage in the first instance.[19]

Of those patients who require chest drain insertion, the BTS recommends small-bore drains in the first instance.[1] This is based on trial evidence documenting efficacy of between 64% and 87%.[20-22]

There is however, only limited evidence directly comparing large-bore and small-bore chest drains [Table 1]. One retrospective study by Vedam and Barnes comprising 67 patients demonstrated similar efficacy with a success rate of 72% (26/36) for small-bore drains compared with 65% (20/31) for large bore. There was also an improved length of stay (5 days vs. 7 days) but an increased complication rate (25% vs. 10%) and an increased recurrence rate (17% vs. 6%).[23] One subsequent prospective trial by Kuo *et al*. consisting of 33 patients demonstrated similar efficacy between both groups (50% vs. 65.2%) with a lower recurrence rate associated with small-bore drains (20% vs. 56.5%). There was no difference in the length of stay, however the only significant difference between the two groups was that the small drains stayed in for a fewer number of days.[24] Significantly, there was no randomization in allocation to either group and both studies only include small numbers.

Secondary Spontaneous Pneumothorax

SSP occurs in patients with underlying lung disease, most commonly chronic obstructive pulmonary disease and is often tolerated much less by patients meaning that drainage is required more often. Only one retrospective study of 91 patients by Tsai *et al*. appears to directly compare efficacy of varying drain sizes in this condition. As with PSP, similar efficacy was reported with 72.5% (50/69) for small bore with 72.7% (16/22) in the large-bore group. There was no significant difference in terms of length of hospital stay, recurrence rate or complication rate.[25]

Inclusion criteria of two further studies failed to distinguish between primary and secondary pneumothorax. One prospective trial comprising 49 patients directly compared small-bore chest drains with large, and a French retrospective study compared the use of 5Fr catheters normally used for central line insertion with large-bore drains in 212 patients with primary, secondary, traumatic and iatrogenic pneumothorax. The prospective trial by Benton and Benfield demonstrated similar efficacy of 88% (21/24) for small bore compared with 80% (20/25) for large bore. Displacement was higher with small bore (21% v 8%) but complications were greater in the large-bore group which achieved statistical significance (32% v 5%, $P < 0.02$).[26] The larger, retrospective study by Contou *et al*. also demonstrated comparable efficacy of 82% versus 79% and confirmed that the duration of drainage and length of stay were significantly shorter in the small-bore group.[27]

Overall, studies comparing the use of small-bore and large-bore chest drains in pneumothorax are limited in patient numbers and many are confounded by their retrospective nature, however none show statistically significant difference in efficacy with regard to drain size. The cumulative data therefore, suggests reasonable efficacy of small-bore chest drains in the management of pneumothorax, however doubt remains due to the paucity of high quality, prospective, randomized data.

Any potential advantage to a larger bore drain in pneumothorax management is likely to relate to lack of blockage, which may be relevant in patients at risk of tension pneumothorax in which this is a priority, and those with large air leaks. A study assessing airflow through chest drains of varying sizes suggests that even large air leaks can be managed with small drain sizes, but that there is variability of flow according to manufacturer and the use of suction.[28]

The authors recommend that small-bore drains are generally used in pneumothorax management, but that it is rational to consider a large-bore drain in cases of a blocked small drain resulting in tension pneumothorax, and in cases where a large-bore drain is not adequately controlling air leak despite the use of thoracic suction. Such patients will demonstrate physiological evidence of compromise despite a bubbling small-bore drain such as worsened respiratory status, increasing pneumothorax size on imaging or increasing subcutaneous emphysema. Specifically, the use of a large-bore drain in the case of an ongoing air leak where there is no evidence of respiratory compromise and where there is a persistent pneumothorax which is not increasing in size is not rational, as increasing drain size in this situation does not fix the underlying visceral pleural leak.

Malignant Pleural Effusion and Pleurodesis

Malignant pleural effusion is a common problem with an increasing incidence. There are approximately 300,000 new cases/year in the US and the UK combined, with >40,000 of those cases in the UK.[1,5] The majority of patients are symptomatic at presentation and therefore require intervention, of which often the first line is drainage and talc pleurodesis.[1]

The BTS Guidelines recommend first-line use of small-bore chest drains. Of the three comparative studies that the guidelines are based on, two are prospective and one retrospective, but all contain small numbers of patients. Importantly, it should be noted that the BTS guidelines themselves acknowledge that the majority of data which support a pleurodesis success rate using talc of around 70% used larger bore (24–32F) drains.

The first prospective study by Clementsen *et al*. consisted of a total of only 18 patients. Complete resolution of effusion was documented in 6/9 patients in the small-bore group and 6/9 in the large-bore group,

Table 1: Pneumothorax summary

Reference	Type of study	Number of patients	Drain size (Fr)	Drain success (%)	*P*
Primary spontaneous pneumothorax					
[20]	Prospective	79	9	87	
[21]	Prospective	76	5.5 or 7	85	
[22]	Prospective	14	12-20	64	
[23]	Retrospective	67	9 versus 20-32	72 versus 65	0.72
[24]	Prospective	33	8-12 versus NR	50 versus 65	
Secondary spontaneous pneumothorax					
[25]	Retrospective	91	10-14 versus 20-28	73 versus 73	0.88
Undefined pneumothorax					
[26]	Prospective	49	12 versus 20-24	88 versus 80	
[27]	Retrospective	212	5 versus 14-20	82 versus 79	0.6

Success defined as pneumothorax resolution. NR: Not recorded with partial resolution in 1/9 and 2/9 respectively.[29] However, this study was a negative superiority study and cannot therefore be taken as robust evidence of "non-inferiority" of smaller bore drains compared with larger bore. The second study by Caglayan *et al*. consisted of more than double the number of patients and demonstrated overall success of 86.9% (20/23) in the small-bore group compared with 90% (18/20) in the large-bore group.[30] Neither study showed a difference in complication rates.

A retrospective study by Parulekar *et al*. also demonstrated similar recurrence rates between both groups at 6 weeks and 4 months: 45% and 53% for 58 patients with small-bore drains, compared with 41% and 51% for 44 patients treated with large-bore chest drains.[31]

The recently published TIME1 study was a prospective randomized controlled trial designed to assess both pleurodesis efficacy between drain sizes as well as analgesia requirements by directly comparing 12Fr Seldinger with 24Fr surgical drains. There was significantly less pain associated with smaller drains, with a reduction of 6 mm on a 100 mm scale of pain during the time the drain was *in situ*, which would appear to be an advantage, however the degree of reduction in pain is less than the clinically significant margin (14 mm), which suggests that the reduction in pain in this situation is at best modest. Importantly, smaller drains had a higher pleurodesis failure rate 15/50 (30%) versus 12/50 (24%) and therefore failed to meet the prespecified non-inferiority margin. Smaller drains were also dislodged more often 24/57 (42%) versus 74/263 (28%), and talc was administered less often through smaller drains, likely secondary to the higher rate of dislodgement and drain blockage. These data suggest potential significant disadvantages of the use of smaller drains for malignant effusion pleurodesis.

TIME1 is the largest direct comparative study assessing non-inferiority of small drains compared to larger drains for malignant effusion management, and although the trial was underpowered for the pleurodesis outcome, as the number of patients undergoing prior thoracoscopy reduced those suitable for direct comparison, this data questions previous suggestions of similar efficacy.[15] Further direct comparative studies are required to specifically address pleurodesis efficacy with varied drain sizes [Table 2].

Table 2: Malignant pleural effusion summary

Reference	Type of study	Number of patients	Drain size (Fr)	Drain success (%)	*P*
[15]	Prospective	114	12 versus 24	70 versus 76	0.14
[29]	Prospective	18	10 versus 24	67 versus 67	
[30]	Prospective	52	NR versus 32	87 versus 90	
[31]	Retrospective	102	12 versus NR	45 versus 53	

Success defined as either complete drainage or successful pleurodesis.
NR: Not recorded

Pleural Infection

Infection within the pleural space has an approximate incidence of 80,000 cases annually in the USA and UK and is continuing to rise.[1-3,32,33] Mortality is high at approximately 20% at 12 months, however this rises with age and in relation to microbial pathogen and can be as high as 47%.[1,34,35] Drainage is the mainstay of initial treatment of complex parapneumonic effusions and empyema. Classically, this has been performed using a large-bore surgical chest drain, however as with other pathology, small-bore Seldinger drains have dramatically increased in use due to their ease of insertion and patient comfort.

Prospective data available from both the Multicenter Intrapleural Sepsis Trial 1 (MIST1) and MIST2 trials showed no difference in efficacy of drainage of empyema between small-bore and large-bore drains. It is important to note however, that neither trial was designed to assess this variable and that those conclusions were reached on the basis of retrospective analysis. Both trials were instead designed to assess the use of intrapleural lysis in the management of empyema.[34,36]

The MIST1 study group did not randomize patients to particular drain sizes or insertion techniques, but an analysis of 405 of the 454 patients on whom complete data was available has assessed whether the initial drain size influenced any of the predefined outcomes.[13] There was no increase in the mortality rate or requirement for surgery within either group and no significant difference in the length of hospital stay, residual chest radiograph changes or pulmonary function test variables at 3 months. Interestingly, a subgroup analysis of only those patients who had frankly purulent fluid demonstrated better outcomes with a smaller bore drain. While this should not be taken to mean that smaller bore drains are "better" than larger bore drains for purulent patients (due to the inherent bias of subgroup analysis), it is reassuring that a small-bore drain is likely to be efficacious at draining even purulent fluid. The method of insertion, either Seldinger or blunt dissection was also not associated with any significant differences.[13]

There are also a large number of non-comparative studies advocating the use of small-bore drains in pleural infection. This is due to high success rates with some data suggesting success of up to 91%.[37]

Conclusions

Overall, the optimum drain size in the management of various pleural diseases remains controversial. Current guidelines recommend preferential use of small-bore Seldinger chest drains, most likely due to their ease of use and insertion, and perceived improvements in pain and patient comfort. We here argue that "optimum" drain size should be specifically considered according to the pleural disease in question, the intended treatment outcome and the physiology of drainage from the pleural space and that not all pleural drainage procedures are considered equivalent.

Comparative studies are infrequent and are often confounded by their retrospective nature or small numbers. A statistically significant difference in meaningful outcomes between drain sizes or insertion technique has not been demonstrated, however it is important to note that "equivalence" has not been demonstrated either. TIME1, the most recent and largest prospective randomized trial directly comparing drain size in malignant pleural effusion, despite reduced power, showed that small-bore drains failed to meet noninferiority criteria, questioning previous assumptions.

Notably, results may be confounded by the higher complication rate associated with small-bore chest drains and in particular the high rate of dislodgement. It may be possible to exclude this by the development of new stabilization techniques which is an area requiring further investigation.

Current data remains inconclusive on what "optimal" drainage size is, and further prospective, randomized studies are required with careful selection of outcomes to improve patient care and guide evidence-based management.

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Conflicts of interest

There are no conflicts of interest.

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