Intracavity drainage for bullous, emphysematous lung disease: experience with the Brompton technique

G E VENN, P R WILLIAMS, P GOLDSTRAW

From Brompton Hospital, London

ABSTRACT   Twenty two operations have been performed on 20 patients for the relief of symptoms due to bullous lung disease. Open intubation drainage of the bullae was used in all patients, the technique initially devised by Monaldi for the treatment of intrapulmonary tuberculous abscesses having been modified. Three patients died after surgery. Mortality was associated with low preoperative FEV_1 (median 350 ml) and higher preoperative arterial carbon dioxide tension ($Paco_2$) (median 7·8 kPa). Symptomatic improvement was reported by 16 of the remaining 17 patients and was maintained over a median follow up period of 1·6 years. This was accompanied by objective improvement in lung function with a 22% median improvement in FEV_1, an 11% median reduction in total lung capacity, and a 26% median reduction in residual volume. In one patient symptoms were unchanged after surgery. The technique described provides a simple method for decompressing bullae by means of a minimally invasive surgical procedure. It also allows for the treatment of further bullae at a later date by closed intubation under local anaesthetic. It has proved a suitable approach for all but those with the poorest lung function and is now our treatment of choice.

Introduction

Dominant bullae are well recognised in association with advanced and generalised emphysematous lung disease. Various surgical techniques have been developed in an attempt to excise the dominant bullae, to allow any underlying compressed and potentially functional lung tissue to re-expand. Techniques that have been used include simple ligation, plication, and segmental or lobar resection, though none of these is ideal. Many patients benefit from surgery, sometimes dramatically; but it has sometimes proved difficult to equate symptomatic improvement with improvement in respiratory function.

Patients referred as potential candidates for surgery frequently have substantial respiratory impairment and surgery is therefore not without risk, from sputum retention, pneumonia, and respiratory failure. Mortality in some series has been as high as 26%.[1]

Intracavity intubation and drainage, initially introduced in 1938 by Monaldi to drain pulmonary

cavities after tuberculous infection,[2] was later adapted for the treatment of any localised pyogenic intra-pulmonary abscess[3][4] and Monaldi's personal series of cases exceeded 2000.[5] The technique has more recently been advocated for the treatment of bullous emphysema.[6-8]

Techniques using intracavity intubation have potential advantages for the treatment of bullous disease. No lung tissue is removed, and this is important for patients with generalised and progressive lung disease; moreover, emphysematous lung tissue is difficult to suture. In addition, the limited incision and brief anaesthesia needed for the procedure are better tolerated by patients with poor lung function.

The technique described was originally devised for patients whose lung function was thought too poor to allow major thoracotomy and formal excision of the bullae. We have been anxious to explore the limits of the technique and have therefore treated "all comers."

Methods

PATIENTS AND INVESTIGATIONS
Twenty two operations have been performed on 20 patients, of whom 12 were male and eight female; the median age was 56 (range 43–71) years. In all cases the
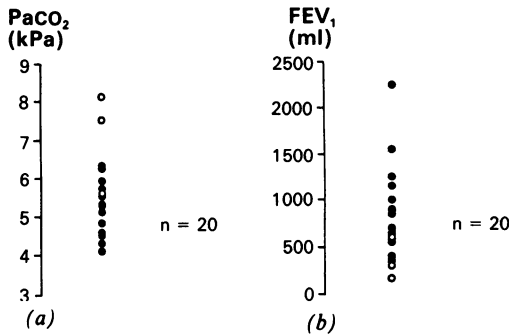
PaCO$_2$
(kPa)

FEV$_1$
(ml)

Fig 1   *Preoperative arterial carbon dioxide tension (PaCO$_2$)
and FEV$_1$ for survivors (●) and those dying (○) after
surgery. p < 0.05, (a) and (b).*

indication for surgery was debilitating dyspnoea in the
presence of dominant discrete bullous disease. All
patients had simple respiratory function tests, includ-
ing routine spirometry and measurement of arterial
blood gas tensions, and in most cases more detailed
respiratory function tests and assessment of lung
volumes were available. All patients had routine
posteroanterior and lateral chest radiography, and
more recently computed tomography has been used
for assessing multiple bullae and planning surgery.
Computed tomography may also allow accurate three
dimensional measurement of the bullae, both before
and after surgery. The earlier patients in the series did
not have computed tomography evaluation of bulla
size.

SURGERY
We have modified the original technique of Monaldi,
incorporating suggestions from other surgeons. We
use a single stage technique, as advocated by
MacArthur,[6] instilling sclerosant directly into the
bulla to produce rapid contraction and fibrosis within
the bulla (McCluskie, personal communication) and
inducing pleurodesis to minimise the immediate effect
of any air leak in the pleural space. The latter will allow
other bullae to be treated later by percutaneous

drainage under local anaesthesia. We were initially
concerned that the intrapulmonary insufflation of
sclerosant might produce bronchoconstriction as
bullae may be ventilated by a major bronchus, but this
has not occurred.

Operative procedure
A limited thoracotomy (10 cm) is performed, to resect
a portion of the underlying rib. The site of the incision
is determined according to the site of the bulla and the
disposition of adjacent compressed lung tissue. We
aim to position the base of the decompressed bulla so
that it is as close to the incision as possible. The pleura
is opened and the bulla incised, and two concentric
polypropylene purse string sutures are inserted around
this incision. The interior of the bulla is inspected and
the septa perforated to allow free communication with
adjacent loculae or bullae. Iodised talc is liberally
insufflated into the bulla cavity. A large Foley catheter
(size 32 FG) is inserted into the cavity via a separate
stab incision in the chest wall, and the balloon is
inflated with 30–40 ml air to function as a self retaining
intrapulmonary drain. The purse string sutures are
secured. The remaining free pleural cavity is liberally
insufflated with talc to obtain a thorough post-
operative pleurodesis. An intrapleural drain is inserted
at the most dependent part of the pleural space and the
wound closed. Slight traction on the intrapulmonary
drain causes the bulla to lie adjacent to the chest wall.
Postoperatively the Foley catheter, lying within the
bullae, remains on free underwater seal drainage. The
air leak from this drain is frequently brisk. The
intrapleural drain remains on underwater seal suction
at 2–5 kPa. It is removed when any air leak has
stopped, usually within 48 hours. The Foley catheter is
removed at 8 days, irrespective of residual air leak. The
patient is able to mobilise during this time with a single
underwater seal drain carried in a suitable transporter.
This period allows a secure bronchocutaneous fistula
to form. After removal of the drain this bronchocutan-
eous fistula spontaneously closes within the ensuing
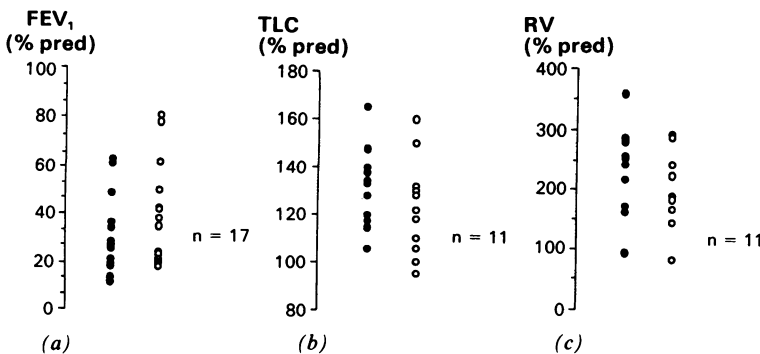24–48 hours, after which the patient is discharged from

FEV$_1$
(% pred)

TLC
(% pred)

RV
(% pred)

Fig 2   *FEV$_1$, total lung
capacity, and residual
volume (RV) before (●)
and after (○) surgery (data
expressed as percentages of
predicted values). p < 0.02
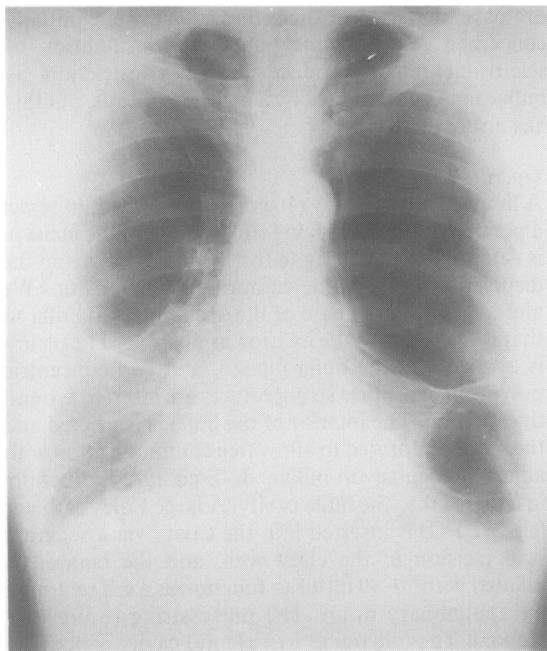(a), < 0.05 (b), and 0.01
(c).*

Fig 3   *Preoperative chest radiograph from a patient with bilateral bullous disease.*
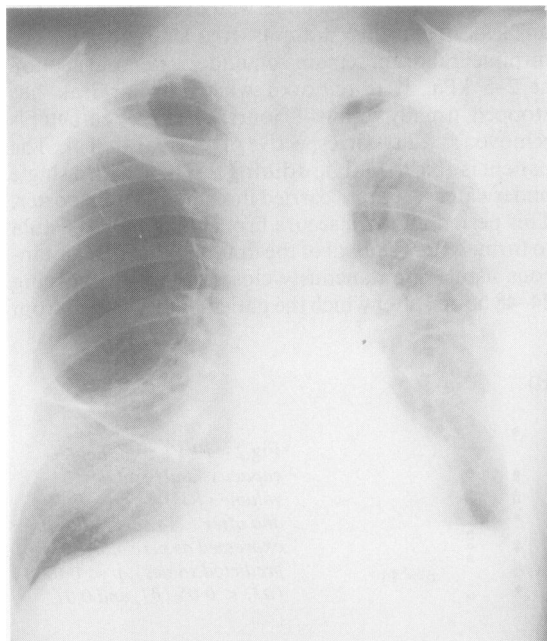

Fig 4   *Postoperative chest radiograph from the same patient after left sided surgery.*

hospital.

The data were not normally distributed. Paired data were analysed with the Wilcoxon signed rank test and unpaired data with the Mann-Whitney U test.

Results

Three of the 20 patients died in the postoperative period. Two of the deaths were due to progressive respiratory failure and the third to staphylococcal septicaemia.

The preoperative FEV_1 ranged from 220 to 2130 (median value 740) ml. Fifteen patients had an FEV_1 of less than 1 litre. The median FEV_1/FVC ratio was 34% (range 17–50%). The preoperative arterial carbon dioxide tension ($Paco_2$) ranged from 4·2 to 8·2 kPa with a median value of 5·2 kPa. Patients who died after surgery were more likely to have had a low preoperative FEV_1 (p < 0·05*) and a higher preoperative $Paco_2$ (p < 0·05*) (fig 1). The two patients dying of respiratory failure had severe impairment of lung function before operation with FEV_1 values of 220 and 350 ml, the former having α_1 antitrypsin deficiency. In the remaining 17 patients there was a 22% median improvement in FEV_1 (p < 0·02)†, fig 2), an 11% median reduction in total lung capacity expressed as a percentage of the predicted value (p < 0·05†, fig 2), and a 26% median reduction in residual volume (p < 0·01†, fig 2). The residual volume (expressed as a percentage of the total lung capacity) fell from a median of 69% to 59% after surgery (p < 0·05†). Radiological improvement was seen in all patients (figs 3 and 4). Subjective improvement was reported by all but one patient, who remained unchanged. The improvement has been maintained so far for all but two patients over a median follow up period of 1·6 years. In both patients deterioration was attributable to formation of further bullae. Percutaneous drainage was performed again in both cases, under local anaesthesia, with additional symptomatic improvement.

Discussion

The presence of bullous disease in association with generalised emphysema is well recognised and presumably represents what Sir John Floyer was describing as the "cystic alterations in the lungs in broken winded horses" in *A Treatise of the Asthma* in 1717.[9] In this work Floyer suggested invasive treatment for the condition.

> The cure of the broken wind cannot easily be projected any other way but by a paracentesis in the thorax, for if the external air be admitted, it will

*Mann-Whitney test; †Wilcoxon rank sum test.

compress the flatulent tumour and through the same
hole a styptic and carminative hydromel be injected,
to restore by its stypticity the tone of the membranes,
and discuss by its aromatic acrimony the windy spirits
or air retained in the lungs.

The surgical treatment of such bullae was not
popularised until the early to middle part of this
century. Such surgery has typically been "bullec-
tomy": formal resection of lung incorporating the
bullae, the resection ranging in magnitude from a
small wedge of pulmonary tissue to one or occasion-
ally more lobes. Occasionally a bulla presents itself as
a discrete "cyst" on a narrow based pedicle, allowing
simple ligation and removal without the excision of
any underlying pulmonary tissue. This usually occurs
without associated emphysema. The mortality
associated with surgery has ranged from 2% to
26%.[1 6–13 15–17] Death is usually due to progressive
postoperative respiratory failure, precipitated by
pulmonary infection in patients with poor lung
function. Their condition is aggravated by the
occurrence of a persistent air leak and the attendant
immobilisation after pulmonary resection, to which
these patients are particularly prone because of their
underlying emphysema. For this reason some authors
have advocated the use of Teflon pledgeted sutures for
such tissue.[18]

Patients presenting with bullae usually have
moderate or severe respiratory impairment, as in our
own series, with a low FEV_1 and other evidence of
airflow obstruction. Such patients cannot usually
tolerate any further reduction in their respiratory
performance, however brief. The best results from
surgery, in terms both of mortality and of symptoms,
have been when bullae have been removed or
decompressed without resection of lung tissue or
alternatively when the resection encompasses an entire
lobe.[3 4 7 8 13]

The assessment of patients for surgery has proved
difficult. Earlier reports noted that the best results
were in those patients in whom the bulla exceeded one
third of the volume of the affected hemithorax and
whose respiratory function was not complicated by
generalised emphysema.[7 14 15 16] Wesley[10] advocated
preoperative indium perfusion scanning to identify
patients with large, discrete, perfusion defects as a sign
of larger, discrete bullae. Other techniques have been
advocated. Logan (personal communication) found
bronchography of value in assessing the distribution
of emphysema within a lobe and the compression of
adjacent lung tissue. Most surgeons have relied on
posteroanterior and lateral chest radiographs, choos-
ing to operate only on patients with radiographic
evidence of parenchymal "compression" adjacent to
the bulla. Latterly, in our own series, we employed
computed tomography and this allowed visualisation

of intrathoracic bullous disease far superior to that
afforded by conventional radiology. It will distinguish
large discrete bullae from more generalised
emphysema, where bullous surgery is often
inappropriate and unrewarding.

Many observers have had difficulty in equating the
subjective improvement reported by patients after
surgery for bullous disease with improvement in the
results of conventional lung function tests.[10 11 14 16 17]
Some sceptics argue that this indicates the placebo
effect of surgery in this condition. The alternative
suggestion, that we cannot easily define and measure
the cause of dyspnoea in these patients, may be more
realistic. In our own series subjective improvement
correlated well with improved spirometric results and
reduction in total lung capacity and residual volume.
The absence of any improvement in arterial blood gas
tensions and carbon monoxide transfer factor would
argue against the relief of lung compression as the
cause of the subjective improvement. The reduction in
lung volumes would cause a reduction in the work of
breathing and this, combined with a reduction in the
sensation of discomfort, possibly from chest wall
stretch receptors as a result of the reduction in chronic
hyperinflation of the chest, may play an important
part in the symptomatic improvement reported by
these patients.

Monaldi's technique of closed intubation drainage,
initially used for the treatment of post-tuberculous
and subsequently other localised pyogenic abscess
cavities, has been advocated by others for the treat-
ment of bullous disease.[6 7] It was initially described as a
two stage procedure. The first stage was to obtain a
pleurodesis with the extrapleural insertion of an iodine
soaked pack,[6 7] which was subsequently removed, the
wound being allowed to heal before the second stage of
catheter insertion and suction drainage of the bulla.
We have combined these two stages to allow a
satisfactory pleurodesis and drainage of the bulla to be
carried out at the same time. The technique has the
great appeal of requiring a very limited surgical
approach and avoids resection of underlying lung
tissue, which is important for these patients with
limited respiratory reserve. The use of computed
tomography has greatly facilitated the selection of
patients, allowing exclusion of those with generalised
emphysema accompanying their bullous disease, in
whom surgery produces poor results. It has also
allowed better preoperative planning of the surgical
approach by localising underlying compressed
pulmonary tissue. This enables the surgical incision to
be positioned to allow the base of the bulla and the
intracavity drain to lie adjacent to the chest wall after
decompression. The technique was valuable in treat-
ing the two patients who presented after their initial
surgery with further bulla formation. The pleurodesis

obtained at the initial operation allowed intubation and drainage of the new bullae percutaneously under local anaesthesia, without risk of pneumothorax.

We have attempted to push this technique to the limit and now recognise that, although highly suitable for patients with poor respiratory function, two of the three patients who died had respiratory function (FEV_1 220 and 350 ml) that was too poor to allow even minimally invasive surgery. The percentage improvement in lung function provided by this technique would have left these patients still housebound and bedridden. We now accept a preoperative FEV_1 of 500 ml as a minimum prerequisite for surgery. This may seem somewhat arbitrary; but we believe that this level of lung function offers safe surgery, and the order of improvement to be expected by this technique will provide an important improvement in the quality of life of such patients.

References

1 Hugh Jones P, Ritchie BC, Dollery CT. Surgical treatment of emphysema *Br Med J* 1966;i:1133–8.
2 Monaldi V. Tentativi di aspirazione endocavitaria nelle caverne tuberculari del polmone. *Lotta Contro la Tuberculosi* 1938;9:910–1.
3 Monaldi V. Endocavitary aspiration in the treatment of lung abscess. *Dis Chest* 1956;29:193–201.
4 Head JR. Intracavity (Monaldi) suction. *J Thorac Surg* 1946;15:153–61.
5 Monaldi V. Endocavitary aspiration: its practical application. *Tubercle* 1946;28:223–8.
6 MacArthur AM, Fountain SW. Intracavity suction and drainage in the treatment of emphysematous bullae. *Thorax* 1977;32:668–72.
7 Head JR, Avery EA. Intracavitary suction (Monaldi) in the treatment of emphysematous bullae and blebs. *J Thorac Cardiovasc Surg* 1948;18:761–76.
8 Head JM, Head LR, Hudson TR, Head JR. The surgical treatment of emphysematous blebs and localised vesicular and bullous emphysema. *J Thorac Cardiovasc Surg* 1960;40:443–60.
9 Floyer JA. *A treatise of the asthma*. 2nd ed. London:1717.
10 Wesley JR, Macleod WM, Mullard KS. Evaluation and surgery of bullous emphysema. *J Thorac Cardiovasc Surg* 1972;63:945–55.
11 Knudson RJ, Gaensler EA. Surgery for emphysema. *Ann Thorac Surg* 1965;21:332–62.
12 Sung DT, Spencer Payne W, Black LF. Surgical management of giant bullae associated with obstructive airway disease. *Surg Clin North Am* 1973;53:913–20.
13 Potgieter PD, Benatar SR, Hewitson RP, Ferguson AD. Surgical treatment of bullous lung disease. *Thorax* 1981;36:885–90.
14 Rogers RM, DuBois AB, Blakemore WS. Effect of removal of bullae on airway conductance and conductance volume ratios. *J Clin Invest* 1968;47:2569–79.
15 Pearson MG, Ogilvie C. Surgical treatment of emphysematous bullae: late outcome. *Thorax* 1983;38:134–7.
16 Fitzgerald MX, Keelan PJ, Cugell DW, Gaensler EA. Long term results of surgery for bullous emphysema. *J Thorac Cardiovasc Surg* 1974;68:566–87.
17 Pride NB, Hugh-Jones P, O'Brien EN, Smith LA. Changes in lung function following the surgical treatment of bullous emphysema. *Q J Med* 1970;39:49–69.
18 Parmar JM, Hubbard WG, Matthews HR. Teflon strip pneumostasis for excision of giant emphysematous bullae. *Thorax* 1987;42:144–8.