though it was used in human patients, many of the results in animal studies in which the role for etomidate in pro
tection against focal brain ischemia was investigated were
correct but suggested a detrimental effect.1,2,9 Second,
as Drummond et al., point out these conflicting pre
clinical data may be explained in part by a better understand
ing of physiology. Nitric oxide may play an important role because it is a local vasodilator. Its functional presence
may be necessary to deliver drugs and metabolites, includ
ing oxygen to hypoxic cells. As Drummond and colleagues
imply, adequate blood levels of any cerebral protectant, or
even global measures of brain function, such as burst sup
pression, are of little value unless the substance and critical
metabolites actually reach the vulnerable cell.

We thank Drs. Chow and Rasmussen for the careful read
ning of our paper. We agree there are inherent flaws in any
retrospective analysis, and we indicated our results should
be regarded as preliminary. They are, however, provocative
in light of a growing body of evidence suggesting that blood
transfusion may be deleterious to some patients, includ

ing trauma patients, in a critical care setting.7,8,10,12 Certainly
many of these studies that examined blood transfusion in
the intensive care unit included few neurosurgical patients.
Rather than simply “believe” that patients with SAH repre
sent a different subset of critical care patients, it is necessary
to have proven that this is true. Retrospective analyses such
as ours are a starting point for the generation of hypotheses
rather than providing proof of cause and effect because, as
Chow and Rasmussen correctly point out, there are always
design flaws. We hope our study will challenge them and
others to prove or disprove our hypotheses rather than con

inue to believe that our current management is adequate.
It is not, because even today half of the patients who suf
fer aneurysm rupture die and a third of survivors make a
full recovery.4 Twenty years ago death among patients
with severe adult respiratory distress syndrome was nearly
universal; today it is uncommon. This dramatic improve
ment occurred because our colleagues in pulmonary medi
ne and critical care questioned accepted medical practice:
would lowering the accepted tidal volume provided to ven
tilated patients make a difference? It did and continues to
make a difference.1,4

Peter D. Le Roux, M.D.
Penn Neurological Institute
Philadelphia, Pennsylvania

References
1. The Acute Respiratory Distress Syndrome Network: Ventilation
with lower tidal volumes as compared with traditional tidal vol
umes for acute lung injury and the acute respiratory distress syn
2. Drummond JC, Cole DJ, Patel PM, Reynolds LW: Focal cerebral
ischemia during anesthesia with etomidate, isoflurane, or thiopen
tal: a comparison of the extent of cerebral injury. Neurosurgery
37:742–749, 1995
3. Edelman GJ, Hoffman WE, Charbel FT: Cerebral hypoxia after
etomidate administration and temporary cerebral artery occlusion.
4. Hickling KG, Henderson SJ, Jackson R: Low mortality associated
with low volume pressure limited ventilation with permissive hy
percapnia in severe adult respiratory distress syndrome. Intensive
5. Horn J, de Haan RJ, Vermeulen M, Luiten PG, Limburg M: Ni
modipine in animal model experiments of focal cerebral ischemia:
6. Le Roux P, Winn HR: Management of the ruptured aneurysm,
in Le Roux P, Winn HR, Newell DW (eds): Management of Cerebral
303–333
ano LM: Blood transfusion, independent of shock severity, is as
associated with worse outcome in trauma. J Trauma 54:898–907,
2003
E, et al: Is a restrictive transfusion strategy safe for resuscitated
and critically ill trauma patients? J Trauma 57:563–568, 2004
9. Milde LN, Milde JH: Preservation of cerebral metabolites by eto
midate during incomplete cerebral ischemia in dogs. Anesthesiolo
igy 65:272–277, 1986
10. Sherr AF, Duh MS, Kelly KM, Kollef MH, CRIT Study Group: Red
blood cell transfusion and ventilator-associated pneumonia: a
11. TRUST study Group: Randomised, double-blind, placebo-con
trolled trial of nimodipine in acute stroke. Lancet 336:1205–1209,
1990
JAMA 288:1499–1507, 2002

Fractions, Stages, Radiosurgery, and Radiotherapy
To the Editor: I wish to thank Kondziolka, et al., for
their recent article (Kondziolka D, Lunsford LD, Loeffler
JS, et al: Radiosurgery and radiotherapy: observations and
clarifying the importance and role of the neurosurgeon in
radiosurgery.

Abstract
Object. Radiosurgery and radiation therapy represent important
but unique treatment paradigms for patients with certain neoplasms,
vascular lesions, or functional disorders. The authors discuss their
differences.
Methods. Reviewing the authors’ experiences shows how the roles of these approaches vary just as their techniques differ. The distinct differences include the method of target localization (intra
operative compared with pretreatment) and irradiation (focused compared with wide-field), their radiobiology (effects of a single
high-dose compared with multiple fractions), the physicians and
other health personnel involved in the conduct of these procedures
(surgical team compared with radiation team), and the expectations
that follow treatment. During the last decade, considerable confusion has grown regarding nomenclature, requisite physician training, and the roles of the physician and surgeon. Ten years ago, two task
forces on radiosurgery were created by national organizations in
neurosurgery and radiation oncology to address these issues of pro
cedural conduct and quality-assurance requirements. At the present
their recent article (Kondziolka D, Lunsford LD, Loeffler
JS, et al: Radiosurgery and radiotherapy: observations and
clarifying the importance and role of the neurosurgeon in
radiosurgery.

Abstract
Object. Radiosurgery and radiation therapy represent important
but unique treatment paradigms for patients with certain neoplasms,
vascular lesions, or functional disorders. The authors discuss their
differences.
Methods. Reviewing the authors’ experiences shows how the roles of these approaches vary just as their techniques differ. The distinct differences include the method of target localization (intra
operative compared with pretreatment) and irradiation (focused compared with wide-field), their radiobiology (effects of a single
high-dose compared with multiple fractions), the physicians and
other health personnel involved in the conduct of these procedures
(surgical team compared with radiation team), and the expectations
that follow treatment. During the last decade, considerable confusion has grown regarding nomenclature, requisite physician training, and the roles of the physician and surgeon. Ten years ago, two task
forces on radiosurgery were created by national organizations in
neurosurgery and radiation oncology to address these issues of pro
cedural conduct and quality-assurance requirements. At the present
time these guidelines are widely ignored. Currently, many patients,
payers, and regulatory agencies are bewildered. What are the differ
ences among stereotactic radiosurgery, fractionated radiation thera
py, and stereotactic radiation therapy? Radiosurgery is to radiation
therapy as microsurgery is to “microtherapy.”
Conclusions. In this report the authors discuss terminology, train
ning, and physician roles in this expanding field.

They note that the neurosurgeon, through advanced train
ning in the management of a wide variety of neurological disorders amenable to radiosurgery and training in neuro
anatomy and image interpretation, in stereotactic surgical

586
procedures and in the use of computerized image-guided navigation, is central to the planning, treatment, and delivery of radiation in radiosurgical procedures. The above authors have built on the pioneering work of Lars Leksell and others in creating new possibilities.

The success of radiosurgery in the past several decades, far from wedging us to doctrine, has provided a more eclectic appreciation for the potential of emerging technology and the capture of the synergy of radiation and biological dose partitioning in treating primary and metastatic disease. Changes in technology have increased the versatility and repertoire of irradiation in neurosurgery. Their article discusses the role of the neurosurgeon in radiosurgical procedures of extracranial targets in which a frame is not used, such as CyberKnife frameless stereotactic radiosurgery. At the University of Pittsburgh, they have demonstrated the safety of this technology in single fractions, and with one to five fractions at Stanford1 and Georgetown University,2 in part due to beam delivery accuracy (without frame) of less than 1 mm.

We have greatly expanded our ability to treat difficult lesions around the central nervous system (CNS). The radiobiology of adverse irradiation effects, as pointed out by Kondziolka, et al., warrants in some situations, splitting and treating arteriovenous malformations in two stages, to reduce adverse radiation effects to normal surrounding CNS tissue. This same rationale can be expanded to other lesions near critical structures, such as the optic nerves and spinal cord, where dividing the treatment into two or more stages is sound, based on the fact that normal CNS cells more faithfully undergo DNA repair than do neoplastic cells after irradiation. An example of how we use staged irradiation is offered in Figs. 1 and 2. A patient with an intradural meningioma at the T-10 level that caused severe pain and progressive paraparesis was unable to undergo surgery due to cardiac disease. The patient received 2500 cGy in five stages; at 8 months she was without pain and ambulating normally.

Staging treatments may also, depending on the dose and timing, exploit the potential benefits of reoxygenation and cell cycling. Through staging treatments we can push higher doses of irradiation while operating within the limits of critical structure dose tolerances established through a century of radiation oncological practice. Radiation oncologists and physicists bring to radiosurgical treatment a corporate experience that lies outside the domain of neurosurgical training.

Perhaps, while acknowledging the pioneering strides in radiosurgery made by Kondziolka, et al., it is appropriate in the presence of an emerging technological field to accept a