Getting an Edge on Success

By
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Every bowhunter is seeking one thing, a successful hit, yet far too few give any consideration to the critical difference the type of cutting edge they have on their broadhead makes between success and failure. Let's look at some facts about your broadhead's cutting edge and how it potentially affects your bowhunting success rate. Let's look first at edge finish.

When all else is equal there's absolutely no question which type of edge finish makes a cut that bleeds the longest and most freely; it's the one made by the thinnest, sharpest, smoothest edge. That's a medical and physiological fact. Why? Because the thinner, sharper and smoother the cutting edge the less disruption there is to the cells lining the inner wall of each blood vessel cut. What does disruption of the blood vessel's inner cell-lining have to do with the rate and degree of bleeding from a cut? Disruption of these cells is what initiates the blood's clotting process, known as coagulation.

Each vessel-lining cell that's disrupted releases the protein prothrombin. As prothrombin comes into contact with the blood's plasma it is converted to the enzyme thrombin. Thrombin acts as a catalyst, converting fibrinogen in the blood into fibrin; the final chemical reaction required for blood coagulation. Coagulation stops or retards the rate of hemorrhaging - exactly what the bowhunter does not want to happen.

The 'rougher' a cutting edge is the more it mangles the tissues, tearing rather than slicing cleanly. That means more vessel-lining cells will be damaged, and the amount of disruption to each damaged cell will be greater. The more cells damaged, and the greater the damage to each cell, the greater the amount of prothrombin released. The more prothrombin released, the more thrombin produced. The more thrombin there is, the more fibrinogen converted to fibrin. The more fibrin produced the shorter the clotting time. The shorter the clotting time, the sooner blood loss decreases and/or stops. The sooner the bleeding subsides, the less the total blood loss.

Here are blood's coagulation steps in a flow chart format.

Hemorrhaging Flow Chart

Disruption of the inner lining of vessel wall initiates release of the protein prothrombin

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Prothrombin reacts with blood plasma to form the enzyme thrombin

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Thrombin catalyzes the conversion of fibrinogen into fibrin

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Fibrin attaches to tissue tags at the edge of the cut, sealing the vessel to reduce/stop hemorrhaging

Note the chart's last step; "Fibrin attaches to tissue tags at the edge of the cut, sealing vessel to reduce/stop hemorrhaging". This is a mechanical step in coagulation, and the type of edge finish on your broadhead has a major impact at this stage of the hemorrhaging cycle too. These 'tags' are near-microscopic loose strands of tissue along the edge of the incision, to which the fibrin readily attaches itself. Just as it damages fewer cells lining the vessel wall, a thin, smoothly honed, truly sharp cutting edge creates fewer tissue-tags along the course of the cut it makes.

Having as few tissue tags as possible is not only important at the point of vessel laceration, it's important along the entire wound channel, from the point of entry to the exit wound. The smoother and more tag-free the entire course of the wound channel, the less 'clogging' of the wound channel that occurs secondary to coagulation. A smooth, tag-free wound channel promotes the free flow of blood throughout the wound, improving the rate and degree of both internal and external bleeding. A smoothly honed and stropped, truly sharp broadhead not only increases the rate, duration and total volume of hemorrhaging it promotes a better blood trail.

The difference in clotting effect between different types of finishes on a 'sharp' edge isn't highly significant when a major (large diameter) vessel is *severely* lacerated or severed. It does, however, become a very important factor when a large vessel is merely nicked, or when only small-diameter vessels have been severed - such as on a marginal liver, kidney or lung hit. The degree and duration of a freely flowing wound is especially important on a shot hitting only one-lung, and is a huge factor on muscle-tissue or pure gut hits; hits into areas where there are fewer major vessels to sever. Recovering an animal after a 'muscle only' or gut hit is entirely possible, especially when the wound channel through the gut, heavy muscle or a large muscle group is lengthy, with many capillaries being severed, but recovery requires that bleeding from the capillaries continue unabated and that careful and correct follow-up procedures be used.

Another, often overlooked wound where the type of edge finish becomes very significant is one through the muscle tissues of the heart. The heart muscle, more so than any other tissue, is designed to seal off wounds to reduce the loss of blood. An edge finish that promotes coagulation merely assists the heart muscle's innate tendency to seal the wound, stopping or retarding the bleeding. As with major blood vessels, the type of edge finish on your broadhead will have little effect on a wound passing through multiple heart chambers, but with a wound that merely nicks a heart chamber, hits only one of the heart's chambers or hits only the muscle of the heart wall, the type of edge finish can have enormous impact on hemorrhage and recovery rates.

As noted above, there isn't a highly significant difference when a major vessel is severed. Clotting alone isn't going to seal that off, but here's another hemorrhaging factor to consider. There is overwhelming medical evidence that a shaft which remains in the wound channel contributes (applies) direct pressure on the wound, reducing the rate of blood loss. This is why first responders are cautioned to never remove a penetrating object from a wound until the patient is in a setting where the increased blood loss that results from the object's removal can be dealt with.

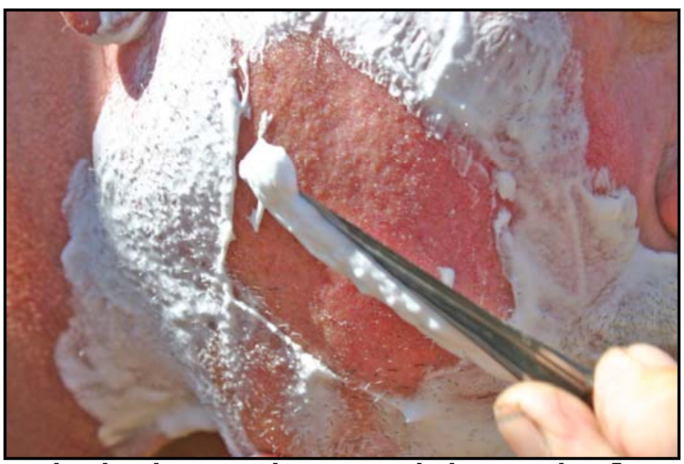
According to research by the Royal Academy of Veterinary Surgeons, when an arrow shaft remains in the wound AND the animal continues to move the pressure between shaft and wound is further increased, additionally retarding blood loss. This is one of the reasons why it is very desirable to get a pass-through shot on as many hits as possible.

The combination of these factors; direct pressure of the shaft on the wound and shortened clotting time created by a sharp but rough, ragged cutting edge; can result in hemorrhagic sealing, or near-sealing, of even substantial wounds; significantly retarding onset of physiologic shock and ensuing collapse. At the best this means a longer blood trail of lesser degree. At the worst it means an animal mortally wounded and not recovered. Even with a pass-through hit, clotting time always becomes a very important recovery-rate factor when only small-diameter vessels have been severed.

Cut Efficiency

Now let's go back to the very start; "When all else is equal, there's absolutely no question which type of edge finish makes a cut that bleeds the longest and most freely; it's the one made by the thinnest, sharpest, smoothest edge." There are many who contend that 'all else' is not equal; that a ragged, serrated or scalloped edge cuts more tissue than a straight, smooth, sharp edge. The theory expounded is that the irregular edge 'grabs' the tissue, ripping and tearing at it, whereas a smooth edge allows the tissue to move along the edge without being cut. Besides the coagulation factors discussed above there are several flaws to this reasoning. Consider the following.

(1) No one who's ever shaved with one would disagree that a rough-edged razor grabs at both whiskers and tissues, but it certainly doesn't cut whiskers as effectively as a sharp, smoothly honed razor. And there's absolutely no doubt that the rough-edged razor is also going to rip many small chunks of tissue from the face, but all those lacerations together will not shed the volume of blood that comes from a single nick with a truly sharp razor.



As this un-retouched photo shows, with a single pass a smoothly honed and stropped, truly sharp broadhead shaves as cleanly as any straight razor. CAUTION: Never try this unless you are practiced at shaving with a straight razor!

(2) Whenever fibrous tissues, such as skin, tendons, ligaments and fascia are penetrated, testing shows that the irregularities along a roughly-finished edge quickly become clogged with strands of tissue fiber. This clogging is present for "Hill type" serrations, the marks left by file sharpening and micro-serrations left by final sharpening with anything short of an extremely fine-grit steel or stone. In sever cases

this clogging becomes so extensive that that the edge is rendered incapable of cutting tissue, even when considerable pressure is applied, but even a few strands of clinging fibers markedly reduces cutting effectiveness. And there's more.

Testing different edge finishes on different types of broadheads in fibrous tissue. The target is multiple layers of fresh Asian buffalo skin, 7" thick. Each arrow was shot first with a smooth, honed and stropped edge, then with a smoothly file-sharpened edge and finally with an edge having 'Hill type' serrations. Each arrow's result was compared to its own results with the other edge types. In every case the smooth, honed and stropped edge penetrated deeper, cutting more tissue. Clinging fibers were present on the edge of every file sharpened and serrated edge.

The Asian buffalo skin is extremely fibrous. The smoothly sharpened, honed and stropped edge of my 3" blade Case sheath knife virtually unzipped the hide with little effort. The 'super sharp' scalloped edge of a Spyderco knife required a forceful sawing motion to slice the hide. Try it yourself!

(3) Testing also shows that a smoothly sharpened, honed and stropped edge, free of all serrations and burrs, penetrates tissues easier than one having a rough edge. On all except pass-through shots that means a longer wound channel for the smooth edge. A longer wound channel means more vessels and capillaries will be encounters by the broadhead, increasing the opportunity to cut vessels.

Next, we have the scalloped edge. An often cited example of a scalloped edge working better than a smooth, non-scalloped edge is serrated steak knives vs. non-serrated ones. There are several reasons why serrated-edge steak knives are widely used, and often *seem* to cut our mealtime steak with more ease than the straight-edged steak knives commonly encountered. The chief reason is that not many folks have steak knives with high quality steel, and even the few who do (at least among those I've encountered) don't keep them well sharpened. The other factors all revolve around the steak on our plate already being dead, butchered and cooked.

Our dinner steak doesn't have a covering of fibrous skin, and the fibrous connective tissue remaining in the steak has been modified by cooking. As our early ancestors all knew, cooking connective tissue - skin, sinew, tendon, ligament, horn or hoof - softens it. Cook it long enough and it becomes liquid, making good glue.

Slicing tissues requires a sharp edge. If a smooth edge is not sharp it has great difficulty cutting through even soft tissues; it has to tear them, rather than slicing through them. Even when dull, a scalloped, rough or serrated edge has an irregular, abrasive surface. When the edge is dull this makes it easier for the edge to tear at the tissues, but not easier for it to *slice* tissues.

Crucially, in living tissues there are bones our arrow must cut or break. Arrows can't neatly carve around bones, as we do when eating our steak. Bone is the most difficult tissue your hunting arrow will be called upon to deal with, and bone contact occurs on the vast majority of hits. Bone doesn't *cut* well with anything short of an offset-tooth saw blade. The thin projections of a scalloped edge are fragile, and easily damaged on hard bone impact. Once damaged they greatly reduce cut effectiveness and markedly increase arrow drag, reducing penetration.

Having serrations on the cutting edge also reduces the broadhead's overall mechanical efficiency; its ability to use whatever amount of force it carries. For elevating a resistance load; which is precisely what a broadhead does as it penetrates; a smooth, gradual inclined plane does the most work with the least applied force. That's why wheel chair ramps are a straight incline – and why they don't have 'speed bumps'. If a load could be raised to the same level with less force by using a concave, convex or scalloped-surface wheel chair ramp you can darned well bet they would be made that way!

Have you ever tried field dressing or capeing a big game animal with a scalloped edge knife; even one with a sharp edge? Have you also field dressed or caped one with a knife having a truly sharp, smoothly honed and stropped edge? Is so, you won't need any convincing which edge cuts more efficiently. If your broadhead isn't truly sharp then you're probably better off with a scalloped or serrated edge, but it's a poor, poor substitute for a truly sharp edge.

Need more proof? Drop by any butchery shop, assuming you can still locate one in this day of pre-packaged everything, and see how many scalloped edge knives these folk who make their livelihood slicing through tissues have on hand. Neither scalloped nor serrated edges *cut* tissues as well as a smooth, sharp edge – but they will *tear* through tissues better than a dull, smooth edge.

About here someone is going to say, "But the knapped edge of a flint broadhead is a scalloped edge, and has fine serrations all along it, and everyone agrees they 'cut better' than steel broadheads". Few edges cut more efficiently than the *ultra-thin* edge obtained by removing a flake from flint or obsidian; but one that does can be found on *smoothly polished* obsidian scalpel blades, which, in pre-laser days, were often used during delicate eye surgery. An obsidian scalpel cuts more cleanly than any steel blade, and cleaner than the finest knapped obsidian edge. Why? Because it's highly polished edge, as thin as that of the finest obsidian flake, has absolutely *no serrations*. Its cut is fully as smooth and flawless as that of a surgical laser, but the laser's advantages of pinpoint focus and simultaneous cauterization of cut vessels has antiquated the obsidian scalpel.

Broadhead and Edge Design

There are also many features of your broadhead's design that affects the quality of the cut it makes as it passes through the tissues … aspects few bowhunter's think about, but should. Foremost is the quality of the steel in the blade, and this is the 'cure' for your thin, smoothly honed and stropped edge losing its sharpness before it has finished penetrating the tissues. If your broadhead is truly sharp at impact but no longer truly sharp when it exits then the steel in the blade is not strong enough for the edge bevel you have on the broadhead.

Softer steels are easier to sharpen, but are not strong enough to resist damage when the edge is thin. At any sharpening angel the cutting edge on softer steel will dull more quickly than were it on harder steel. To compensate for this folks sharpen softer-steel broadheads at a more abrupt angle. This helps with the edge retention but sacrifices the advantages of a thin edge; one sharpened at a lower angle and having a better mechanical advantage. As long as the edge is truly sharp and smooth, why does this matter? It's more than just the thinner edge damaging fewer of the cells lining each vessel's wall.

At equal levels of sharpness, the mechanical advantage of a broadhead's edge bevel affects the *quantity* of the cut achieved. The lower its total sharpening angle the higher mechanical advantage an edge bevel has. Think of the edge bevel as a simple wedge (if double-beveled) or simple inclined plane (if single-beveled). The longer the bevel's slope in relation to the rise (the blade's thickness) the higher the bevel's mechanical advantage will be.

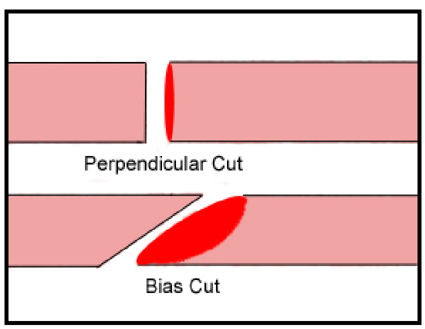
Having a higher mechanical advantage means an edge can do more 'work' at whatever amount of tension the broadhead creates between the tissues and the edge; and we'll talk more about tissue-to-cutting-edge tension in a moment. Compared to an edge having a lower mechanical advantage, a higher mechanical advantage *edge bevel* slices equally well at less tissue-tension … or you could just as well say, at the same level of tension between the tissue and the cutting edge a higher mechanical advantage edge will slice deeper.

Much discussion has been directed towards (overall) broadhead mechanical advantage and the increased penetration-potential offered by long-narrow heads, but such broadheads offer another characteristic worth consideration. The longer a broadhead's cutting edge, the greater the distance tissues travel along the edge. Increased tissue travel-distance along the edge increases contact time, offering the blade greater opportunity to sever the tissues.

To see the difference greater tissue-travel and longer contact time makes, place the edge of a sheet of paper against a sharp blade's edge. Keeping even pressure of paper to blade, push or pull the paper along the blade. The greater distance the paper is moved, the more deeply it is sliced. What you're observing is *increased cutting potential resulting from greater travel-distance*. With broadheads, a longer length cutting edge increases the likelihood that each blood vessel encountering the edge will be severed. Why the "Keeping even pressure of paper to blade" qualifier? This brings us back to tissue-tension against the cutting edge.

A broadhead acts as a compound-wedge during penetration. Blade width and thickness, ferrule-taper and edge-bevel all spread tissues at an angle to the blade's edge. This tensions pliable tissues against the edge, making them easier to slice; much as a tensioned rubber band slices more easily than one that's lax. In soft tissues, broadhead rotation induced by a single-bevel design also spreads the tissues, creating additional tissue-tension and increasing cut-efficiency. The rotating single-bevel broadhead also causes tissues to be dragged forcefully across the blade's sharp edge at an angle to the forward motion of the cutting edge.

Having the broadhead rotate as it penetrates not only enhances the slicing effect, it cuts more of the vessels encountered on a bias (obliquely, at an angle). As shown in the illustration, a vessel of equal diameter will have a larger opening in the vessel wall when it's cut on a bias, as opposed to a right-angle cut. This makes it more difficult for coagulation alone to seal the cut, promoting faster and freer bleeding. Yes, blood vessels do travel in all directions and every broadhead will cut many of the vessels encountered at a bias, but having the broadhead rotate greatly increases the *mathematical probability* of cutting each vessels at a bias – even when initial edge contact with the vessel is perpendicular.



So there you have it, just what every bowhunter seeks; the broadhead edge that works the best. Good quality steel in the broadhead's blade, while requiring more effort to sharpen, allows you to use a thinner edge with higher mechanical advantage while still retaining blade sharpness throughout the entire course of penetration. The high mechanical advantage of the low angle edge-bevel cuts more efficiently at any given level of sharpness and tissue tension. Using a longer length cutting edge increases tissue-to-edge contact time, increasing the slicing effect. A single-bevel edge induces rotation, increasing the degree of tissue tension, dragging tissue forcefully across the edge at an angle to the cutting edge's direction of forward motion and cutting more vessels on a bias, inhibiting coagulation and promoting freer bleeding. And last … but really first and foremost … on any given hit that thin, smoothly finished, truly sharp edge creates a cut that bleeds longer and more freely than any other cutting edge.

Nothing … absolutely nothing … does more for success than fast collapse time and, except for nerve center and locomotion disabling hits, fast collapse time depends on the rate of blood loss. Giving your broadhead an edge for success not only yields faster collapse, better blood trails and shorter recoveries on those fanciful 'perfect hits', it gives an enormous advantage whenever your hit is less than perfect. And it doesn't hurt to enhance the penetration potential of your arrow setup, improving your odds for a total pass-through hit. You don't want that arrow shaft hanging around in the wound channel an longer than absolutely necessary. Preventing shaft pressure on the wound will make the most of the advantages you've just gained from your broadhead's newly optimized cutting edge … and each gives you an edge on success.