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We characterize the small-time asymptotic behavior of the exit probability of a Lévy process out of a two-sided interval and of the law of its overshoot, conditionally on the terminal value of the process. The asymptotic expansions are given in the form of a first order term and a precise computable error bound. As an application of these formulas, we develop a novel adaptive discretization scheme for the Monte Carlo computation of functionals of killed Lévy processes with controlled bias. The considered functionals appear in several domains of mathematical finance, including barrier options, structural credit risk models, and contingent convertible bonds. (Received March 04, 2013)